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CHILD DEVELOPMENT

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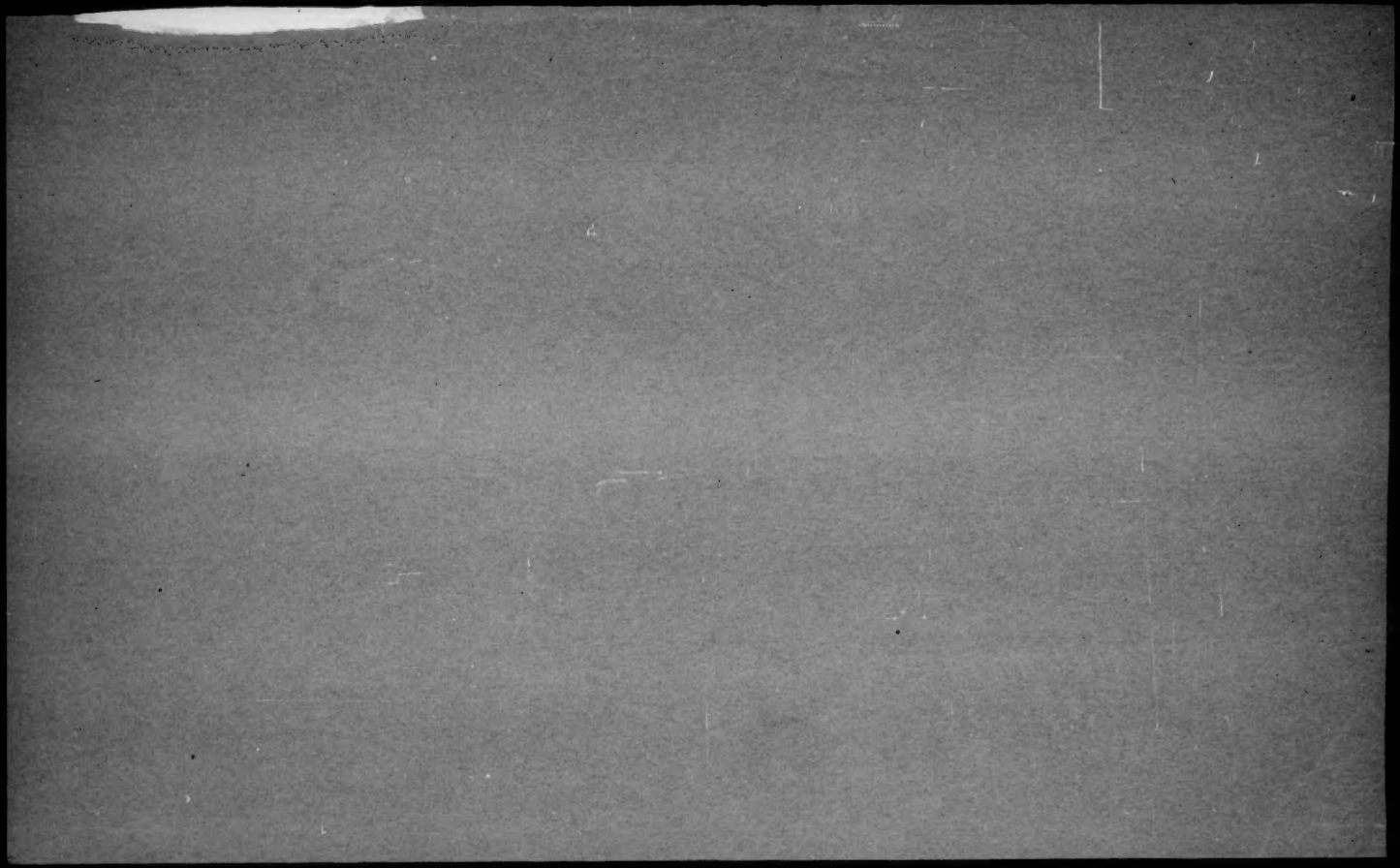

CHILD DEVELOPMENT

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A STUDY OF THE RELATION OF INTELLIGENCE, FAMILY SIZE, AND SEX DIFFERENCES WITH MUTUAL FRIENDSHIPS IN THE PRIMARY GRADES[1]

MERL E. BONNEY

A number of techniques have been used by different investigators to determine mutual friendships. The most important of these are: teacher judgment (16), observation of spontaneous contacts (22), the Guess Who device (13), the paired comparison technique (11), direct questioning of the subjects as to their best friends (6), and the use of pupil choices in various situations that naturally arise in classroom activities (5). In the study which is herein reported the last two of these methods were utilized. The data were gathered over a two-year period (1940-1941) during which time the pupils studied were in the second and third grades of three schools in Denton, Texas. The three schools consisted of two public schools and the demonstration school associated with the North Texas State Teachers College. Denton is a town of approximately 12,000 population. Although the study followed the pupils through the two years there were numerous changes in the pupil personnel between the two grades. School A (Demonstration School) had the most stable population, but even here with a class of 23 children 26 per cent of the third graders had not been in the second grade. In School B (Sam Houston School) with a typical class of around 33 there was a difference of 30 per cent in the population of the third grade over the second. In School C (Robert E. Lee School) with a typical class size of 34 there was a difference of 41 per cent in the third over the second grade. These changes in pupil personnel meant many changes in interpersonal relationships. Consequently, the data for the third grade should not be regarded as being obtained on the same children who were simply a year older.

In order to make clear the basis for the mutual friendships a brief description of the choosing situations will be given. There were three situations which were common to all the schools both years. One was the taking of pictures in October. The children listed three others in the room with whom they would like to have their pictures taken. They were told to put their choices in order of preference. The pictures were taken and each child received a print. Another common choosing situation was in December of each year. The pupils wrote the names of all the children to whom they would like to give Christmas presents, as well as those to whom they were actually going to give presents. The latter were given higher scores since it was assumed that they represented a closer degree of attachment. The third situation utilized in all three schools was the giving of Valentines in February. The scores in this instance were obtained by taking the Valentines out of the

[1] *North Texas State Teachers College, Denton, Texas.*

The writer wishes to express his appreciation to the school officials and teachers of Denton who have given their wholehearted cooperation in this study. These include: Superintendent R. C. Patterson, Dr. J. C. Matthews, Mr. J. L. Yarbrough, Mr. C. J. Walker, Miss Epsie Young, Miss Eva Stapleton, Mrs. Una Gibbons, Miss Roberta Rogers, Mrs. R. N. Lukens, Miss Glenna Harris, and Mrs. Edyth Miller.

boxes a few hours before they were distributed and recording the names of all the children who gave to each child.

In addition to the choosings mentioned above there were three others in the second grade in School A. These were:

November, repeat of the picture taking situation.
April, stating choices of children they would prefer to go home with after school.
May, selecting one preferred as a partner on a bus trip taken by the group.

In School B in the second grade there were three additional choosing situations as follows:

January, choosing a child to sit by at the beginning of the second semester.
March, selecting a partner for the group trip to the zoo.
May, listing preferences of children to go home with after school.

In School C on the second grade level there were five additional choosing situations. These were:

January 8, choosing partners for a class trip on a train.
January 21, naming children they would prefer to sit by at the beginning of the second semester.
March, electing a child to hold a fossil while a group picture was taken (the fossil had played an important part in a class project).
May, listing preferences of partners for marching to the Teachers College to see a flower exhibit.

In the third grade in School A there were three other choosing situations in addition to those mentioned above. These were:

November, making sketches of friends in the art class.
April, the giving of Easter cards.
May, choosing others with whom to work on committees for a social event.

The additional voting situations in the third grade in School B were:

April, preferences for partners on trip to Ft. Worth to visit the packing house.
May, voting for class librarian.

In School C in the third grade the additional situations were:

November, making sketches of friends in art class.
April, selecting partners for an Easter party.

May, choosing those they would prefer to sit near in the fourth grade in the fall.

In October choices for having pictures taken, each child was limited to three choices but in all the others the children were told to write down as many names as they wished. In a few cases as many as 14 names were written. It was thought that the technique of unlimited choices would result in a more adequate appraisal of each child's status.

In order to state the different degrees of social acceptance in numerical terms the following system of scoring was utilized: Each first choice was given a score of 5, each second choice a score of 4, each third choice a score of 3, each fourth choice a score of 2, each fifth choice a score of 1, and all other choices a score of 1. It was thus possible to determine the score value which each child gave every other child in all the choosing situations. By adding these scores for all these situations for a school year it was possible to give each child a total mutual or unreciprocated friendship score in respect to every other child in the group. No child was included in the final scoring unless he was present for at least 75 per cent of the choosing situations during the year. Nearly all those included in the study were present in all the choosing situations.

The different degrees of mutual acceptance or rejection were classified as follows: very mutual, moderately mutual, weakly mutual, largely unreciprocated, and very unreciprocated. These groupings were determined on the basis of a percentage of the total maximum score. The maximum score possible was the score which one child would receive from another child if that child voted for him in the first place in all the choosing situations during a school year. In School A in the second grade there were five opportunities for voting. Thus, the highest mutual friendship score possible in this grade was 25. When there were eight choosing situations the maximum score would be 40.

The standard for very mutual friendships was that each child gave the other one 41 per cent of the maximum score vote. The standard for moderately mutual was that each child gave the other one 30 per cent of the maximum. The standard for weakly mutual friendship was that each child gave the other one 20 per cent of the total possible score vote. The "largely unreciprocated" group was made up of those combinations of pupils in which one gave the other one a total score vote approximately equal (within two points) to the standard for moderately mutual and received in return a total score vote equal to less than the standard for weakly mutual. The "very unreciprocated" group was composed of those combinations of pupils in which one gave the other one a total score vote equal to or greater than the standard for very mutual friendship and received in return a total vote less than the standard for weakly mutual. Since the same percentage basis was used in all three schools it was possible to combine the results in these schools even though a different number of choosing situations were utilized.

The above standards were set up after the data had been accumulated. This was necessary since it was not possible to know in advance how frequently the pupils would vote for each other. Whatever may be the intrinsic value of the above system of classification there would seem

to be no doubt but that the various groups represent different degrees of attraction and repulsion in interpersonal relationships. This is shown by the average scores of each group. On the second grade level in School A the very mutual friends gave each other a total average score of 16, the moderately mutuals gave each other an average of 10, and the weakly mutuals gave each other an average of 8. The "largely unreciprocating" friends gave a total average score of .65 while they received in return from those seeking their friendship an average of 7. The "very unreciprocating" friends gave a total average score of 1.2 while they received in return from those seeking their friendship an average of 14. The figures for Schools B and C follow very closely those given above except that in School C the differences between the unreciprocated friends were more marked, amounting to a difference of .24 to 13 for the "largely unreciprocated" and a difference of .19 to 20 for the "very unreciprocated" friendships.

On the third grade level in School A the very mutual friends gave each other a total average score of 12.5, the moderately mutuals gave each other an average of 10.2, and the weakly mutuals gave each other an average of 8. The "largely unreciprocating" friends gave a total average score of 2 while they received in return from those seeking their friendship an average of 8.8. The "very unreciprocating" friends gave an average score of .58 and received in return from those seeking their friendship an average of 12.5. The figures for Schools B and C are quite similar to those for School A.

The figures given above would seem to lead to the conclusion that the various groups were well differentiated on the basis of degree of mutual attraction and rejection.

RELATION OF INTELLIGENCE TO MUTUAL ATTRACTION AND REJECTION

The intelligence quotients (I. Qs.) utilized in this study were obtained from the administration of the California Test of Mental Maturity in the first and second grades and the Kuhlman-Anderson Test in the third grade. In approximately half of the cases the I. Qs. used were the averages of three years' testing. In another 20 per cent the scores were based on two years' testing, and the remainder on one year only. The large number of I. Qs. which were based on more than one test increases the validity of the measurements.

The relationships found between intelligence test results and the various degrees of mutual attraction and rejection are given in Table 1.

All the coefficients for the different degrees of mutuality given in Table 1 are positive whereas three of those for unreciprocated friendships are negative and the remaining one zero. When the results for the two grades are averaged it becomes evident that there is a trend for the higher degrees of mutuality to be more closely associated with intelligence, although the relationship is not completely consistent. From the very mutual pairs on through the unreciprocated pairs the averages run: .33, .35, .23 -.16, -.03. Although the reliability figures given in Table 1 show that most of the coefficients do not have complete statistical reliability, they are nevertheless in line with results from other similar studies. Working with elementary school

TABLE 1

CORRELATIONS OF INTELLIGENCE TEST QUOTIENTS WITH VARIOUS DEGREES OF MUTUAL AND UNRECIPROCATED FRIENDSHIPS AND WITH TOTAL MUTUAL FRIENDSHIPS SCORES

Very Mutual	Moder. Mutual	Weakly Mutual	Largely Unrecip.	Very Unrecip.	Total Mutual Scores: School A	School B	School C
SECOND GRADE							
21 pairs	24 pairs	33 pairs	58 pairs	53 pairs	22 cases	21 cases	26 cases
.41±.12	.29±.14	.16±.13	-.16±.08	.07±.09	.39±.13	.40±.12	.27±.12
THIRD GRADE							
19 pairs	38 pairs	38 pairs	36 pairs	28 pairs	19 cases	22 cases	21 cases
.26±.15	.42±.09	.30±.10	-.17±.11	-.13±.12	.51±.11	.02±.15	.44±.12

children Seagoe (16) reports a correlation of .51 between the I. Qs. of a selected group of mutual friends, but only .36 between children who were less consistent friends. Using pupils from the fourth through the seventh grades as subjects, Almack (1) found correlations with intelligence of .30 and .31 for boy and girl friendships respectively. Jenkins (9) obtained a coefficient of .332 for 180 junior high school mutual friendships. Pintner, Forlano, and Friedman (14) report correlations of .62 and .60 between mental ages of friends but only .15 and .10 for I. Qs. Dimock's (6) study of the intelligence of 38 pairs of mutual friends among adolescent boys resulted in an r of .55. Lippitt (11) gives correlations of .07, .38, and .31 between the I. Qs. of mutual friends in three nursery school groups.

The general trend of all these results can scarcely leave any doubt but that similarity in intelligence is one factor in determining mutual friendships. A practical application of these findings is the suggestion to parents that they make sure their children are able to associate with others who are of an approximate degree of brightness. This is probably most pertinent in respect to the very bright child who lives in a small community where there are few others of his degree of intelligence.

The last three columns for both grades in Table 1 are concerned with total mutual friendship scores. These scores were determined by giving a count of 3 for each very mutual friendship, 2 for each moderately mutual, and 1 for each weakly mutual friendship. Each largely unreciprocated relationship was scored a -1 and each very unreciprocated relationship was scored a -2. The algebraic sum of these points made up the total mutual friendship scores. Thus a child with one very mutual, one moderately mutual friendship, and one largely unreciprocated friendship would have a total score of 3+2 -1 = 4. These scores ranged from +16 to -9. It can be seen from Table 1 that all the coefficients for the total mutual friendship scores are positive and that they range

from .02 to .51. The average of the correlations in the second grade is .35 and of those in the third grade is .32.

The fact that the correlations are not higher than they are should serve to emphasize the point, frequently made to parents, that intellectual brightness on the part of their children by no means guarantees the acquisition of social skills or the techniques and attitudes essential to successful living. Although, as pointed out above similarity in intelligence is undoubtedly a factor in determining mutual attraction and rejection it is only one of a constellation of influences making for social acceptance.

FAMILY SIZE DIFFERENCES IN MUTUAL FRIENDSHIPS

The data to be considered first in respect to family size are summarized in Table 2.

TABLE 2

RELATION BETWEEN NUMBER OF SIBLINGS AND DEGREE OF MUTUAL FRIENDSHIPS IN SECOND AND THIRD GRADES
All Figures in Per Cents

	SECOND GRADE			THIRD GRADE		
Family size of pairs of Mutual Friends	Very Mutual 21 pairs	Moderately Mutual 24 pairs	Weakly Mutual 28 pairs	Very Mutual 19 pairs	Moderately Mutual 38 pairs	Weakly Mutual 38 pairs
Both Only Children	19	17	4	11	8	8
Only child with child having one or two sibs.	29	25	36	32	29	26
Only child with child having three or more sibs.	19	4	7	15	8	18
One or two sibs. each	19	29	21	10	15	8
Child with one or two sibs. with child having three or more sibs.	14	21	28	21	26	34
Both having three or more sibs.	0	4	4	10	15	5

The most outstanding point established by the data in Table 2 is the very favorable social position occupied by the only child. This position becomes much more significant when the proportion of only children in the total group is considered. In the second grade there were altogether 79 families. Of this number 19 per cent had only one child. Inspection of Table 2 will show that 67 per cent (19 + 29 + 19) of the very mutual friendships on the second grade level involved an only child. Also that 46 per cent (17 + 25 + 4) of the moderately mutual and 47 per cent (4 + 36 + 7) of the weakly mutual friendships involved an only child. Such differences between the proportion of only children in the total group and the number of their mutual friendships is certainly contrary to the prevalent idea that the only child is apt to be maladjusted socially. This point is further emphasized by the data on the third grade level. In this grade there were altogether 68 families of which 23 per cent consisted of only one child. Table 2 shows that 58 per cent (11 + 32 + 15) of the very mutual friendships involved an only child and that this was true of 45 per cent (8 + 29 + 8) of the moderately mutual friendships and of 52 per cent (8 + 26 + 18) of the weakly mutual friendships. With but one exception, and that by only one point, (moderately mutual in the third grade), all the percentages cited above are more than two or three times as great as the number of only children in the population studied.

The favorable social position of the only child receives additional emphasis from the data on unreciprocated friendships which are presented in Table 3.

TABLE 3

RELATION BETWEEN FAMILY SIZE AND UNRECIPROCATED FRIENDSHIPS IN SECOND AND THIRD GRADES
All Figures in Per Cents

	SECOND GRADE				THIRD GRADE			
Family size of unreciprocated friendships	Largely Unrecip. 57 pairs		Very Unrecip. 50 pairs		Largely Unrecip. 36 pairs		Very Unrecip. 27 pairs	
	Acc. * child	Rej. * child	Acc. Child	Rej. child	Acc. child	Rej. child	Acc. child	Rej. child
Only children	40	12	48	24	30	17	41	29
One or two sibs	37	67	36	58	33	72	37	67
Three or more sibs.	22	20	16	18	36	11	22	2

* Acc.---Accepted
* Rej.---Rejected

On the second grade level the above Table shows that 40 per cent of the "accepted" children among the "largely unreciprocated" friend-

ships were only children, whereas only 12 per cent of the "rejected" children were in the only child group. The corresponding percentages for the "very unreciprocated" friendships are 24 and 12. It should be kept in mind that only 19 per cent of the families in the second grade were single child families. Turning to the figures for unreciprocated friendships in the third grade it is clear again that the only child occupies a social position considerably superior to his numerical strength. With but 23 per cent of the families consisting of an only child, this family size holds 30 and 41 per cent respectively of the "accepted" child position in the "largely" and "very" unreciprocated groups. Only in the latter group does the percentage of "rejected" only children exceed their proportion in the population.

Attention may now be turned to consideration of the only child in relation to the children from the larger family units given in Tables 2 and 3. Due to the differences in proportion of the total population which each family size held it was necessary to translate the data of Tables 2 and 3 into ratios. This is done in Table 4.

TABLE 4

RATIOS OF PERCENTAGES OF MUTUAL FRIENDSHIPS ATTAINED BY CHILDREN IN FAMILIES OF VARYING SIZES WITH THE REPRESENTATION OF THESE FAMILIES IN THE TOTAL POPULATION

	SECOND GRADE			THIRD GRADE		
Family Size	Very Mut.	Mod. Mut.	Weakly Mut.	Very Mut.	Mod. Mut.	Weakly Mut.
Only Child	3.52	2.42	2.47	2.52	1.95	2.26
One or two sibs.	1.07	1.29	1.45	1.34	1.49	1.45
Three or more sibs.	1.43	1.26	1.70	1.59	1.69	1.96

	UNRECIPROCATED FRIENDSHIPS							
	Largely Unrec.*		Very Unrec.		Largely Unrec.		Very Unrec.	
	Acc.*	Rej.*	Acc.	Rej.	Acc.	Rej.	Acc.	Rej.
Only Child	2.11	-.37	2.53	1.26	1.30	-.44	1.78	1.26
One or two sibs.	-.36	1.16	-.38	1.00	-.30	1.74	-.21	1.42
Three or more sibs.	-.04	-.13	-.31	-.22	1.20	-.64	-.27	-.87

*Unrec.---Unreciprocated
*Acc.-----Accepted
*Rej.-----Rejected

The ratios given in Table 4 were obtained by dividing the percentages in Tables 2 and 3 by the per cent which each family size represented in the total population. Among the unreciprocated friendships the minus scores are those instances in which the percentages of

accepted or rejected children are less than the proportion of the total population occupied by a given family size. Two examples will make the procedure clear. The 3.52 for the only child families in the second grade for very mutual friendships was obtained by dividing 19 per cent (proportion of families) into 67 per cent -- the total per cent of a very mutual friendships in which only children were involved. In those cases in which a per cent involved two family sizes, as the 29 per cent for both only children and families of 1 or 2 siblings, this per cent was included in both calculations. The -.36 for the families of two or three children (child studied with one or two siblings) in the second grade for "largely unreciprocated" among "accepted" children was obtained by dividing 58 per cent (proportion of family population into 37 per cent (proportion of accepted children in Table 3) and subtracting this quotient from one. This means that this size family lacked .36 of having as large a representation among the accepted children as would be expected from their numerical strength in the population. It will be noted, however, that a minus score in the column for rejected children is an advantage because it means that the particular family size involved did not have as many rejected children as would be expected from its proportion in the population.

In looking at the ratios in Table 4, the most striking point that emerges is the marked superiority of the only child family over the other two sizes. Without exception, straight through the mutual friendships, the only child is in a superior social position. Among the unreciprocated friendships the single child family maintains its advantage. It has the highest ratios in all the "accepted" child categories and has negative ratios in two of the "rejected" child columns.

Another striking point brought out by the data of Table 4 is the relatively poor showing made by the medium size family of two or three children. With but one slight exception (moderately mutual in second grade) this size family has the lowest ratios in all the mutual categories. (It composed 58 per cent of all the families in the second grade and 47 per cent of the families in the third grade.) This poor social standing is also maintained by the medium size family throughout the unreciprocated friendships. It does not have a single positive ratio among the "accepted" child columns and all its "rejected" child categories are positive, which means more rejected children than its percentage in the population would warrant.

The families of four or more children have (with the slight exception for moderately mutual in the second grade) a consistently better social standing than the medium size families. The large size family composed 23 per cent of the family population of the second grade level and 30 per cent on the third grade level.[2] Although these percentages are considerably less than those for the medium size family, the children from the large families attained more mutual friendships and were involved in fewer unreciprocations on both grade levels. It is true that the differences in the mutual friendships are not generally large but the high degree of consistency lends emphasis to those

[2] *In no case was there more than one child from the same family in any grade.*

differences. There is a marked contrast between the ratios for the medium and large families in the unreciprocated friendships, especially for the rejected children. It will be noted that all these ratios for the medium size family are negative. On the third grade level these differences are striking. It is difficult to explain why the children from large families should be so consistently superior to those from medium size families. The data in this study do not offer any explanation of this finding.

Since the data given in Tables 2, 3, and 4 are based on considerable overlapping of names because of the fact that most of the children were involved in a number of different pairs in various degrees of attraction and rejection, it is important to see if the same trends hold true in respect to family size when total mutual friendship scores are used. These involve no overlapping, since, as previously explained, they are the algebraic sum of all the mutual and unreciprocated friendships which each child received throughout a school year. In order to show the relation of these total scores to family size all the scores for the three schools were placed in quartiles with the fourth quartile consisting of the children who had the highest total mutual friendship scores and so on down to the lowest. These quartiles are shown in relation to family size ratios in Table 5.

TABLE 5

RATIOS BETWEEN FAMILY SIZE AND TOTAL MUTUAL FRIENDSHIP SCORES

QUARTILES	SECOND GRADE			THIRD GRADE		
	Only child	2 or 3 children	4 or more children	Only child	2 or 3 children	4 or more children
4	1.84	-.19	-.22	1.61	-.34	1.03
3	-.05	1.12	-.05	-.44	-.09	1.43
2	-.16	-.09	1.35	-.09	1.08	-.07
1	1.10	1.10	-.40	-.13	1.55	-.77

The ratios given in Table 5 were calculated in the same manner as those in Table 4. The percentage which each family size had in each of the quartiles was divided by the percentage which that family size occupied in the total population of families for each grade level. For instance, the only children in the second grade constituted 35 per cent of the highest quartile. This number was divided by 19 per cent - the proportion of only child families in the grade - to obtain the ratio of 1.84 in Table 5. As previously explained, the minus figures occur when the percentage of a family size in a given quartile is less than its proportion in the total population. The -.19 above was obtained in the following manner: The medium size family composed 47 per cent of the families in the upper quartile. This was divided by 58 per cent - proportion of population - giving .81. This figure was subtracted from 1 - giving -.19 - which is the extent that this size family fell below its representation in the population. Since the fourth quartile in Table 5 is the highest, it is obvious that a positive score shows a favorable social position in the two upper quartiles and a minus

score shows a favorable social position in the two lower quartiles.

An analysis of the data in Table 5 shows that the three family sizes follow the same alignment as found in Table 4, but not quite to the same degree of consistency. The only child family still occupies the most favorable social position - having the highest positive ratios in the uppermost quartile and only one positive ratio in the lower groups. In the third quartile the only child does not fare so well, but one of the negative scores (-.05) is very slight. The medium size family continues to be in the most unfavorable social position - having three negative ratios in the two upper quartiles and three positive ones in the lower divisions. The large family, as before, stands in a midway position to the other two, since it has only two negative scores in the two highest categories and has three negative ratios in the lower groups - two of which are quite high.

Another aspect of the family size data not included in the above tables is worth mentioning, that is, the number of siblings within five years of the age of the child studied. This is of value because it may be assumed that with children in the second and third grades a brother or sister who is more than five years older or younger than they are would not be apt to constitute a playmate for them. When these data were assembled in respect to the quartiles on total mutual friendship scores given in Table 5 it was revealed that the most popular children in both grade levels had the smallest number of brothers and sisters who could be considered playmates. In the second grade the average number of siblings per child ran as follows: first quartile .86, second quartile .95, third quartile .82, fourth quartile .52. In the third grade the average number of siblings ran: first quartile .80, second quartile .78, third quartile .81, fourth quartile .50. The most significant point about these figures is the definitely lower averages for the children in the highest popularity quartiles in both grades.

Another source of comparison of the various family sizes in relation to the social success of their children is available in teacher ratings. These ratings were obtained by a five point scale consisting of twenty traits, such as adaptable, cheerful, independent, sociable, tactful, etc. (7). They were obtained in the third grade only. All ratings were made by the three teachers involved during the months of November and December. Combining the data for the three schools into family sizes of only children, two or three children, and four or more children, and determining the average teacher rating score for each group, the following results were obtained: only children (13 cases) Mean=15; medium size family (29 cases) Mean=4.5; large family (17 cases) Mean= 7.5. The median scores for the three family sizes ran respectively: 10, 6, 7. Here is a striking parallel with the results obtained by the pupil choices. Although the teacher ratings were obtained on 20 personal traits, not just friendships or popularity, the results in relation to family size correspond exactly with those obtained for mutual friendships by pupil choices throughout the school year. Again the only child group stands highest, followed by children from large families, and lowest of the three, the medium size family. The figures above show the most marked differentiation on the basis of averages, but the medians follow the same order. This evidence, together with that on pupil choices, would seem to conclusively establish the social superi-

ority of the only child in the groups studied. Why the medium size family so consistently falls below the large family is again not clear.

It was thought that some light might be thrown on family size differences from data on economic status. Since a scale for this purpose was not administered, the only information available in this area was the fathers' occupations. However, the writer has considerable personal acquaintance with the financial circumstances of the families studied, having visited approximately half of the homes and knowing many details about the kind of work done by the fathers. On the basis of this knowledge the families were placed into four groups, number one being the lowest in economic level. This lowest group consisted of those on relief or having very irregular and poorly paid employment. Groups two and three were made up of those having regular employment but of different levels of income. The number four group was composed of children of college faculty members (of which there were only three), owners of a business, and a few others known to be in good circumstances. When these data were related to family size it was found that the only children had a superior economic rating on both grade levels to the other two family sizes, but that there was practically no difference in the ratings of the medium and the large families. The only children had ratings of 2.8 and 2.9 in the second and third grades whereas the medium and large families had ratings of 2.4, 2.3, 2.2, and 2.2 respectively. Granting the crudeness of the rating scale, it nevertheless seems safe to conclude that the only children as a group came from at least slightly superior economic circumstances. (In considering the differences in the average economic ratings cited above it should be kept in mind that the total scale covered only four points.) From these ratings it can be seen that the poorer showing of the medium size as compared with the large size family cannot be explained on the basis of income level.

Still another factor which might have some value in explaining family-size differences is intelligence. This however did not prove to be the case when the central tendencies of the I. Qs. for the three family sizes were calculated. In the second grade the means ran: only children-105, medium size family-105, large family-107. On the third grade level the figures were respectively 108, 106, and 104. The medians did not vary significantly from the means. None of the differences is large enough to warrant a conclusion that one size family had an advantage over the others in degree of brightness.

Summarizing the material that has now been presented on family size, it may be said conclusively that the only child is in a socially superior position to children from other size families in all three schools and on both grade levels. As a group the only children came from a somewhat superior economic status. To what extent this was a causative factor in determining social success cannot be definitely stated, but it is undoubtedly a factor. Why the children from medium size families fall consistently below those from large families in social success cannot be answered from the data available. It may be only a peculiarity of this particular sampling of families.

The findings of this study (and of another one previously published on some of these subjects in respect to general social status on the

second grade level) (2) which show the social superiority of the only child are contrary to many prevalent beliefs. It is quite commonly assumed by teachers, parents and others that the only child is almost certain to be socially maladjusted, particularly by being selfish, dominating and attention-demanding. This attitude is sometimes expressed in psychological writings as evidenced in a 1941 book, in which the author states:

"The only child is apparently more likely to be brought up badly. He is never dethroned by any later children. He is so important to his parents that they are apt to guard him with extreme care; they may spoil him completely and make him selfish, dominating, and egotistical, and at the same time essentially weak in his character structure. He tends to be deeply hurt when he is not the center of interest and attention. He is more likely to have nervous habits."[3]

Although the author is careful to point out that not all only children have these difficulties, the emphasis of the above statement is not supported by the results of studies on family size.

Perhaps the most important point to emphasize from the foregoing data on family size is that after all family size does not tell us much, if anything, about the personality of a given child. The fact that a child has no brother or sister, or has two, four, or eight does not in itself have any explanatory value as to why he is either socially successful or unsuccessful. The same good and bad personality traits are found in children who come from all degrees of family size. The idea that only children are practically certain to be social misfits, whereas children from large families are almost equally certain to be well socialized, is another example of the false assumption that experience is valuable irrespective of the quality of that experience. A child from a large family undoubtedly has many more social contacts than the only child, but some of these contacts result in unfavorable traits, such as sibling rivalry, struggling for parental favors, and in a few cases overdependence on an older brother or sister. Much recent psychology has given particular emphasis to the fact that each individual is in many respects unique. It is this uniqueness that many teachers and other professional workers are prone to disregard in their interest to simplify the problem of understanding behavior by putting people into classes or types. There is no escape from the study of individuals primarily as individuals. The only child should not be viewed with preconceived notions about what kind of personal traits he is going to exhibit simply because he belongs to the class of only children. Neither should it be assumed that if he has some unfavorable traits these are due to his being an only child. Here, as elsewhere, concomitance does not necessarily mean causation. It is quite probable that the social adjustment of a child with others of his age is much more closely related to his psychological relationships with his parents than with the amount of experience he has had with other children.

[3] A. H. Maslow and B. Mittelman, *Principles of Abnormal Psychology*, Harper and Brothers, New York, 1941, p. 265.

The results of this study in respect to the social competence of the only child are in accord with the findings of other similar investigations. Witty (24) compared a group of only children who were seniors in high school with an equal number of classmates who held an intermediate family position, that is, they had both older and younger siblings. Using teacher ratings, a personality inventory, and items from the subjects' developmental history as sources of data, Witty concluded that there were no important differences between the only children and those who stood in the intermediate family position. He says: "The 'onliness' factor is of little significance in the development and adjustment of senior high school students." Leland H. Stott (17) reports a study of 150 only children on the high school level, some of whom had been reared on farms and some in cities. Each only child was matched with a non-only child in respect to place of residence, sex, I. Q., and economic level of family. On the basis of results from a personality questionnaire it was concluded that personality differences between only and non-only children reared on a farm were generally insignificant, and that the only children reared in a city were superior to those from larger families in personal and social adjustment, and in the development of self-reliance and responsibility. The author points out that the ease with which children can be transported to places where they can play with others, and the better education of mothers in child training have probably been important factors in improving the social development of the only child.

SEX DIFFERENCES IN MUTUAL FRIENDSHIPS

The findings in respect to sex differences in various degrees of mutual attraction and rejection are summarized in Table 6.

TABLE 6

SEX DIFFERENCES IN VARIOUS DEGREES OF MUTUAL AND UNRECIPROCATED FRIENDSHIPS

GRADE	Very Mutual Friends			Moderately Mutual Friends			Weakly Mutual Friends		
	% boy-boy	% girl-girl	% boy-girl	% boy-boy	% girl-girl	% boy-girl	% boy-boy	% girl-girl	% boy-girl
Second	32	64	4	29	67	4	34	57	9
Third	43	57	0	23	64	13	52	32	15

	Largely Unreciprocated Friends				Very Unreciprocated Friends			
	% boy-boy	% girl-girl	% boy-*girl	% girl-*boy	% boy-boy	% girl-girl	% boy-girl	% girl-boy
Second	38	41	14	7	26	44	30	0
Third	33	31	25	11	21	53	15	11

*boy-girl means boy friendships unreciprocated by girls
*girl-boy means girl friendships unreciprocated by boys

An analysis of Table 6 reveals the following points: the much larger percentages in favor of girls in the "very mutual" and "moderately mutual" groups in both grades, the small percentages of boy-girl combinations in all three degrees of mutual friendships in both grades, the much larger percentages of girls who are "very unreciprocated" in both grades, and the consistently larger percentages of boys who are unreciprocated by girls as compared with the per cent of girls who are unreciprocated by boys.

The finding in respect to the small percentages of boy-girl combinations among the mutual friendships is corroborated by other studies which have nearly always found that children of the ages being studied form friendships primarily within their own sex rather than between the sexes.

The other findings listed above all bear on the social superiority of girls over boys. It will be noticed, however, that the two middle groups consisting of the "weakly mutuals" and the "largely unreciprocated" are not well differentiated on the basis of sex differences. With these exceptions the girls show a consistently higher degree of social attainment or of interest in interpersonal relationships. The latter point is shown in the larger percentages of girls who are "very unreciprocated" in both grades. This may be considered as being due to the tendency of the girls to reach out more than boys for social contacts so that they establish not only more mutual friendships but also more unreciprocations. This tendency is shown in the greater number of names which the girls wrote down in the choosing situations. A check on those choices in which there was no limit to the number of names which could be written showed that in all three schools the girls averaged from two to four more names than the boys. This shows a greater interest in social contacts.

The striking and consistently larger percentages of girls over boys in the "very" and "moderately" mutual friendships together with the greater unreciprocation of boys by girls must certainly lead to the conclusion that the girls in the groups studied have attained a higher degree of social success than the boys.

The factors which might have a bearing on this sex difference will now be considered.

It may be thought that the greater number of mutual friends among girls is due to there being more girls in the grades studied. This, however, is not the case. On the second grade level the proportion ran: School A, 9 boys and 14 girls; School B, 25 boys and 13 girls; School C, 15 boys and 16 girls. On the third grade level the proportions were: School A, 8 boys and 12 girls; School B, 19 boys and 12 girls; School C, 15 boys and 12 girls. These figures show that with the exception of School A the number of boys equalled or surpassed the number of girls during both school years. Thus from the standpoint of numbers alone the boys had a better opportunity than the girls to establish mutual friendships.

Another aspect of the data bearing on the matter of sex differences in social success is the actual number of different boys and girls in the five degrees of mutual attraction and rejection. Since each child's name is repeated in each of the five categories as many times as he or

she is involved in a mutual or an unreciprocated friendship, there is considerable overlapping of names in each group. When this overlapping is eliminated do the girls still show an advantage over boys in social success? The answer is "yes" without a single exception in respect to the mutual friendships. In all three degrees the girls outnumber the boys on both grade levels. The least amount of difference is in the "weakly mutual" friends on the third grade level where there were 21 boys and 23 girls. This is too small a difference to be significant. The greatest amount of difference is in the moderately mutual group in the third grade in which there are 30 girls and 16 boys. The average of the other differences of girls over boys among the mutual groups is six. When the duplication of names is eliminated from the unreciprocated groups it is found that on the second grade level there are a few more boys than girls, whereas on the third grade level the reverse is true, there being a few more girls than boys. None of these differences is large, the average in the second grade being 4 and in the third grade 3. Thus only among the unreciprocated on the third grade level do the girls appear at a disadvantage over boys when the actual number of cases is considered.

Still another source of evidence on sex differences is in the total mutual friendship scores. As previously stated these scores are the algebraic sums of all the mutual and the unreciprocated choices. On this basis do the girls also show superiority over the boys in social success? The answer is "yes", but not with complete consistency. A summary of findings on this point is given in Table 7 which shows that every difference is in favor of girls except on the third grade level in School A. No reason is apparent for this exception.

TABLE 7

SEX DIFFERENCES IN TOTAL MUTUAL FRIENDSHIPS SCORES

	SECOND GRADE			THIRD GRADE		
SCHOOLS	Ave. for boys	Ave. for girls	Diff. in favor of girls	Ave. for boys	Ave. for girls	Diff. in favor of girls
A	.38	2.4	2.02	5.00	2.8	-2.2
B	2.1	7.1	5.00	2.8	6.6	3.8
C	-1.1	2.8	3.9	1.6	6.7	5.1

As stated in the previous section on family size, teacher ratings on twenty personal traits were available on the third grade level. Did the teachers give the girls more favorable ratings than the boys? The answer is "yes" for Schools B and C but not for School A. In School B the boys received an average rating of 6 on the scale used (7) and the girls an average of 8. This is too small a difference to make anything of. In School C the boys were given an average of 8 and the girls an average of 15. This shows a distinct advantage in favor of girls. In

School A the advantage was equally distinct for the boys, the averages being 5 to 15. This result is in line with the finding that boys had higher total mutual friendship scores than girls in the third grade as given in Table 5. When the teacher ratings for the three schools were combined there was practically no difference in the average scores for the boys and girls. This fact together with the inconsistency of results in the three schools makes impossible a definite conclusion about sex differences in the teacher ratings.

Since the girls in the three grades studied are shown to be generally superior to the boys in mutual friendships, (as well as in general social status as reported in a previous publication) (2), it is important to compare the two sexes in as many other respects as the available data permit in order to help explain this difference.

First, in regard to chronological age - were the girls older than the boys? The answer is "no"; the girls were younger. Taking all three schools together the boys in the second grade averaged three months older than the girls and in the third grade they averaged five months older. These differences were consistent in the three schools.

Did the girls have an advantage in mental age? They definitely did - particularly in the third grade. On the second grade level the girls averaged 4.3 mental age months higher, and on the third grade level 8 months higher. These differences were consistent in the three schools with the exception of School C in the second grade where the two sexes were equal in mental age.

Did the girls exceed the boys in I. Qs.? They did - as would be expected from the previous statements about the boys being older and the girls having higher average mental ages. On the second grade level the girls had a 3 point advantage (99-102) and on the third grade level a 5 point advantage (102-107). These differences are small but they are sufficient, particularly in the third grade, to indicate that the girls may have had a slight lead over the boys in degree of brightness.

Were the girls superior to the boys academically? This is answered definitely in the affirmative on both grade levels. The Gates Reading Test was given in the second grade in the month of May. The results showed that the girls in all three schools combined had an average reading age which was .60 of a year higher than that of the boys. In the third grade the Stanford Achievement Test was given in the month of March. On this measurement the girls' superiority amounted to .41 of a grade level when average scores were used, and when median scores were used the girls' superiority rose to .63 of a grade level. These differences were consistent in all three schools.

Summarizing the foregoing data in respect to sex differences we have a picture of the girls who have reached a higher degree of social success than the boys, and who are also somewhat superior to the opposite sex in mental age, degree of brightness, and in academic achievement. The girls are slightly younger than the boys.

What answer should now be given to the question of why the girls are so definitely and consistently superior to the boys in mutual friendships? Is it because of their superiority in mental development? It is barely possible that this has something to do with it since the

correlations between I. Qs. and total mutual friendship scores as reported in Table 1 show that there is at least a small degree of relationship between the two factors. This relationship, however, is not great enough or consistent enough to be worth much as a source of explanation of sex differences.

To what extent does the greater academic success of girls account for their greater social success? It is not possible to know definitely, but there is some clue in the obtained correlation of .36 ± .07 between reading ages and total mutual friendship scores in the second grade, and the correlation of .41 ± .07 between grade placement on the Stanford Achievement Test in the third grade and total mutual friendship scores. From these coefficients (which are statistically reliable) it may be concluded that it is quite possible that the superior academic achievement of girls played a part in their greater social success, but to what extent or in what manner cannot be answered definitely from the data at hand.

It is quite probable that the superiority of girls in social success, as well as in mental and academic attainments, is due primarily to the well-known facts in respect to the more rapid physiological maturation of girls over boys. The fact, however, that the boys as a group were from three to five months older than the girls would discount the maturation factor to some extent. Also, as is usual with children of this age, the boys averaged four pounds heavier than the girls (59-55) and were one inch taller (53-52).

There are, of course, other possible explanations of the greater social attainments of girls. It may be that the school, as an institution, favors feminine traits over masculine. This is borne out by the disciplinary records which nearly always show a preponderance of boys over girls. Also, practically all elementary school teachers are women. However, it should not be forgotten that boys, as well as girls, have many opportunities to establish social contacts and win friends outside of the school situation. If these opportunities are equal, there should be about the same amount of carry-over into classroom choosing situations.

It is within the realm of possibility that there are certain basic differences between the average male and the average female in their interest in social relationships. There is the old saw about women talking more than men, and there is also the popular notion that love and intimate personal relationships are more essential to the happiness of most women than to the happiness of most men. Data of a more valid nature are those given by L. M. Terman and C. C. Miles in their "Sex and Personality".[4] From their extensive questionnaire study it was discovered that females surpass males in such personal traits as sympathy, pity, and interest in occupations more directly ministrative, particularly to the young, the helpless, and the distressed. These are all social traits.

If it be concluded that the typical female, in our culture at least, is characterized by greater social interest than the typical male, it does not therefore follow that boys cannot be as well socialized as girls, but it may mean that there should be some differences in the

[4]*McGraw--Hill Book Co., 1936, pp. 447-450.*

socializing program, particularly in allowing more leeway for aggressive traits. This particular point is emphasized by the results of an observational study over a period of five years of 66 nursery school children reported by McCay and Fowler (12). Records were kept on various behavior characteristics, including "nervousness", in situations involving eating, elimination, and sleep. From this study the authors state that—

"In addition to greater size, there are the tendencies of the male to be more aggressive and to show more extravert behavior than does the female."

The authors continue with their conclusions as follows:

"We have mentioned the tendency of the male to have a more constant and higher body temperature; to have a higher basic metabolic rate and higher muscular tensions while at rest. It seems fair to take the view that while there are large individual variations, males tend to be larger, more active, more tense, more dominant, perhaps 'higher geared' organisms than are females. Perhaps it is this 'higher geared' effect which accounts for the greater mortality of males in later life, a fact which is true of both the rat and man."

Another interesting point in this connection is the finding of McFarland, Honzik, and Davis (13) that popular boys are often quarrelsome but popular girls are not. In their study this trait showed the greatest sex difference of various factors related to popularity.

Finally, since girls are known to mature more rapidly than boys, it would seem that special efforts should be made to enable boys to attain skill and ease in inter-personal relationships in order to compensate for slower general development. This point is emphasized by the well known fact that there are many more boy delinquents than girls, and that there is a close relation between delinquent behavior and the frustration of social and emotional needs.

SUMMARY

Three degrees of mutual and two degrees of unreciprocated friendships were determined in the second and third grades of three schools in Denton, Texas, during the school years of 1939-1940, and 1940-1941. The various degrees of mutual and unreciprocated friendships were determined by pupil choices, the number of the choosing situations varying from five to eight throughout a school year.

Correlations between the various degrees of attraction and rejection and intelligence quotients showed that generally the closer the degree of mutuality the higher the coefficients, but that all the correlations were low. Relationships between total mutual friendship scores and I. Qs. ranged from .02 to .51 with an average from six coefficients of .34. These data show that although the higher degrees of brightness are definitely associated with the ability to win friends, intellectual brightness is far from being any kind of a guarantee of social competence.

The results on family size showed a consistent superiority in social success for the only child. This held true regardless of how the data were analysed. The only child not only held an advantageous position in mutual friendships but also in unreciprocated friendships. This also held true on the basis of total mutual friendship scores. Furthermore, teacher ratings on twenty personal traits were consistent with pupil choices in giving the only child the most favorable social position.

In an effort to explain the superior position of the only child, this size family was compared with larger units in respect to economic status and intelligence. On the basis of an admittedly crude rating of family income level it was found that the single child family was in slightly superior economic circumstances to larger family units, but that the only children, as a group, were not superior in degree of brightness as measured by group intelligence tests.

On the basis of mutual friendships determined by pupil choices as well as on the basis of teacher ratings, the large family unit of four or more children ranked consistently higher than the medium size family of two or three children. The relatively inferior social position occupied by children from medium-sized families could not be explained from the data available in this study.

When all the children were placed in quartiles on the basis of total mutual friendship scores it was found that those in the highest quartiles in popularity had the smallest number of brothers and sisters within five years of their own age. This difference was quite marked.

The results on sex differences show a consistent superiority in favor of girls over boys in social success as measured by pupil choices. On the basis of teacher ratings the girls were definitely superior in one school whereas in another school the reverse was true. In the third school there was practically no difference. The inconsistency of results would not permit a definite conclusion in respect to sex differences in teacher ratings.

In an effort to explain the superior social position of girls on the basis of pupil choices various factors were considered. It was found that with the exception of one school the girls had a smaller numerical representation than the boys. When overlapping of names was eliminited in the various categories of mutual and unreciprocated friendships the girls still maintained their lead on the basis of actual number of cases in the different groupings. The girls as a group were younger than the boys. They were superior in average mental age. On the third grade level this difference amounted to eight months. The girls' I. Qs. averaged slightly higher. The girls showed a rather marked superiority over boys in academic attainment as measured by standardized tests.

A number of possible explanations for the social superiority of girls were considered. Differences in I. Qs. did not seem to be important enough to be a determining factor, but it was thought possible that differences in academic achievement could have been a factor aiding the girls in their superior social success. It was considered quite probable that the more rapid maturation of girls could be a main factor promoting their social attainment over boys. This was discounted to some extent by the fact that the boys were older than the girls. It

was pointed out that the school may favor feminine traits over masculine and that nearly all elementary school teachers are women. It was thought within the realm of possibility that there are some basic differences between the typical female and the typical male in their interest in social experiences. This is born out by various popular notions as well as by some studies on psychological sex differences.

Even if it be concluded that most females are more socially minded than most males it does not follow that boys cannot be as well socialized as girls, but it may mean that there should be some differences in the socializing program, particularly in respect to allowing more leeway for aggressive traits when boys are involved. This point is emphasized in recent studies on sex differences.

Finally every effort should be made to give boys experience and help in social relationships in order to compensate for their generally slower development. This point is emphasized by studies which show a much greater number of boy over girl delinquents, and the close relation between anti-social behavior and the frustration of social and emotional needs.

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NUTRITIONAL STATUS INDICES FOR RURAL AND URBAN UTAH SCHOOL CHILDREN[1]

ALMEDA P. BROWN AND FAYE Y. MOSER[2]

Height-weight measurements of 13,871[3] school children in Utah cities (population 10,000 or more) and 12,913 school children from farms or towns (population not more than 2,500) showed that the city children were generally taller and weighed more for height and age than did the country children.

Census reports[4] showed practically no difference in the racial stocks from which the two groups of children descended, parents of both city and country populations having come from the same European countries and in practically the same proportions. It was thought desirable, therefore, to investigate nutritional status of groups of city and country children to determine whether these differences in size could be attributed to differences in nutrition. The procedure to be used was that developed by the Child Health Association.[5] The method involves the taking of 7 measurements from which indices or scores are computed reflecting amounts of musculature, subcutaneous tissue, and weight in relation to size of skeleton. It provides therefore for comparison of soft tissues, usually thought to be an indication of recent nutrition, of one child with another or with a group with similar bony structure. Groups may be compared in the same way.

Since these 7 measurements are time-consuming and require a high degree of precision in measuring technique, it was obviously impracticable to measure large numbers of children. For convenience, therefore, one Logan City school[6] and two Cache County schools, one located about 20 miles northwest, and the other 5 miles south of Logan, were selected for study. Measurements were made on 136 children between the ages of 8 and 12 years in the city school and 137 in the county schools. The data show (Tables 1 and 2) that these two groups follow the same general pattern in size relationships as do the large groups reported in Bulletin No. 266 and in the Cache County supplement to the bulletin (see Table 1 in the appendix). The numbers of city (136) and of county (137) children in this study are practically the same; unfortunately, however, their distribution according to sex and age is different. Measurements were taken in the spring (March and April) to eliminate the possibility of complicating differences owing to season. One person made all measure-

[1] *Contribution from the Department of Nutrition, Utah Agricultural Experiment Station - Report on project 184 Purnell. Authorized for publication by the director.*

[2] *Research associate professor of nutrition and research assistant, respectively.*

[3] *Brown, Almeda P. Comparative size of rural and urban Utah school children as determined by the weight-height-age relationship. Utah Agr. Exp. Sta. Bul. 266. 1936.*

[4] *U. S. Bureau of Census. Fifteenth Report. Population, vol. III pt. 2, 1105 (table 19) 1931.*

[5] *The American Child Health Association. Nutritional status indices, method of obtaining measures of musculature, subcutaneous tissue, and weight, with allowance for skeletal build. New York, 1935.*

[6] *This school served as a training school for teacher trainees of the Utah State Agricultural College.*

ments, a second did all recording. A steel tape and calipers approved by the Child Health Association were used.

TABLE 1

COMPARISON OF AVERAGE HEIGHTS OF 136 CHILDREN IN A LOGAN CITY SCHOOL AND OF 137 CHILDREN IN TWO CACHE COUNTY SCHOOLS (AGES 8 TO 12 YEARS)

Age years	Average Height, inches (boys)					Average height, inches (girls)				
	Cache Co.		Logan City		Difference*	Cache Co.		Logan City		Difference
	No.	Av. ht.	No.	Av. ht.		No.	Av. ht.	No.	Av. Ht.	
8	12	50.4	6	50.2	-0.2	9	47.7	2	48.1	+0.4
9	15	52.0	17	52.7	+0.7	17	50.4	13	51.2	+0.8
10	20	53.2	24	53.7	+0.5	10	53.5	17	55.1	+1.6
11	11	54.5	18	55.8	+1.3	12	55.9	15	55.9	0.0
12	10	55.2	14	58.1	+2.9	21	58.8	10	60.5	+1.7

* A negative sign indicates larger average size for the country group.

TABLE 2

COMPARISON OF AVERAGE WEIGHTS OF 136 CHILDREN IN ONE LOGAN CITY SCHOOL AND OF 137 CHILDREN IN TWO CACHE COUNTY SCHOOLS (AGES 8 TO 12 YEARS)

Age years	Average Weight, pounds (boys)					Average Weight, pounds (girls)				
	Cache Co.		Logan City		Difference	Cache Co.		Logan City		Difference*
	No.	Av. wt.	No.	Av. wt.		No.	Av. wt.	No.	Av. wt.	
8	12	59.5	6	60.5	+1.0	9	51.5	2	48.5	-3.0
9	15	59.1	17	65.9	+6.8	17	56.0	13	57.9	+1.9
10	20	68.1	24	68.3	+0.2	10	70.6	17	75.4	+4.8
11	11	70.0	18	75.2	+5.2	12	79.7	15	74.9	-4.8
12	10	73.1	14	84.6	+11.5	21	86.8	10	89.3	+2.5

* A negative sign indicates larger average size for the country group.

The measurements taken and the manner in which indices or scores for musculature, subcutaneous tissue, and weight are computed from these measurements with aid of tables prepared by the Child Health Association are shown in Form 1 in the appendix. A distribution table of these scores on a percentage basis is given in Table 3. The main impression gathered from the data in Table 3 is that neither group excels in the matter of low percentages of indices in the lower levels, nor in high percentages of indices in the higher levels.

One interesting observation in connection with Table 3 is that the country girls have the greatest concentration of two of their three indices (musculature and weight) in the interval 50 - 59.9, while the other three groups have the greatest concentration of indices in the

40–49.9 interval.

A similar situation is seen in Table 4 where Cache County girls constitute the only group having the mean for each of the three indices above 50. Also the standard deviations would indicate slightly less variation in the indices of this group than in those of the three other groups.

Correlation between the various nutritional indices is seen in Table 5 to be of relatively low order except in the case of weight and musculature for both city and country boys and for city girls, in which cases the value of the correlation coefficient is .7 or more. The highest correlation for country girls is also found between weight and musculature.

TABLE 3

PERCENTAGE DISTRIBUTION OF NUTRITIONAL INDICES OF 137 CACHE COUNTY AND 136 LOGAN CITY SCHOOL CHILDREN (AGES 8 TO 12 YEARS)

	Cache County boys			Logan City boys			Cache County girls			Logan City girls		
	M*	S**	W***	M	S	W	M	S	W	M	S	W
Below 30			1.5			5.1					1.7	
30-39.9	11.8	13.3	13.2	2.5	17.7	15.2	1.4	7.3	7.2	3.5	5.3	7.0
40-49.9	30.8	50.0	42.7	32.9	43.0	46.8	18.9	40.6	29.0	26.3	45.6	49.1
50-59.9	23.5	19.1	33.8	45.6	32.9	26.6	52.2	34.8	49.3	38.6	33.3	31.6
60-69.9	28.0	14.7	4.4	12.7	3.8	5.1	23.2	13.0	8.7	28.1	8.8	12.3
70-79.9	4.4	2.9	2.9	5.0	1.3	1.2	2.9	2.9	2.9	3.5	1.8	
80+	1.5		1.5	1.3	1.3		1.4	1.4	2.9		3.5	
Totals (per-cent)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* M indicates musculature.
** S indicates subcutaneous tissue.
*** W indicates weight.

According to a device of the Child Health Association developed for separating out from a group those children in the poorest state of nutrition, those having all three nutritional indices of 50 or less will fall in the lower 29 per cent of the group nutritionally; those having all three indices 46 or less in the lower 15 per cent; and those having all three indices of 44 or less in the lower 9 per cent. The relative ratings of the two groups in this study on this basis are shown in Table 6. The country girls have the smallest relative numbers (as indicated by the percentages in Table 6) at all three levels; only 26 per cent (13.0 + 7.2 + 5.8) of their indices are below 50. The city girls have percentages in each case almost twice as great as those of the country girls. The two groups of boys run nearly parallel in per-

TABLE 4

MEAN NUTRITIONAL INDICES OF 137 CACHE COUNTY AND 136 LOGAN CITY SCHOOL CHILDREN (AGES 8 TO 12)

	Mean* indices with standard deviations							
	Cache County boys		Logan City boys		Cache County girls		Logan City girls	
Indices	Mean Index	Standard deviation	Mean Index	Standard deviation	Mean index	Standard deviation	Mean index	Standard deviation
Musculature	53.7	6.0	53.9	9.0	56.2	7.8	54.8	9.0
Subcutaneous tissue	50.6	11.0	47.7	9.0	51.8	9.0	51.1	9.7
Weight	49.1	10.0	46.5	11.6	53.0	8.7	49.9	8.1

* Arithmetic mean.

TABLE 5

CORRELATIONS BETWEEN NUTRITIONAL INDICES OF 137 CACHE COUNTY AND 136 LOGAN CITY SCHOOL CHILDREN (AGES 8 TO 12)

	Correlation coefficient: (r)			
Indices	Cache Co. boys	Logan City boys	Cache Co. girls	Logan City Girls
Weight and subcutaneous tissue	.59	.48	.38	.48
Weight and musculature	.70	.73	.56	.72
Subcutaneous tissue and musculature	.36	.67	.55	.51

centages of indices in low levels, their total percentages of scores 50 or less are higher than those of either group of girls, but at the 15 per cent and the 9 per cent levels their relative numbers of scores lie between those of the two groups of girls. If, therefore, these nutritional indices really do indicate state of nutrition as reflected in relationship of soft tissues to bony structure, the country girls would appear to be in the best state of nutrition, the country boys second, the city boys third, with the city girls in the poorest state of nutrition. Reference to Table 2 shows the size relationships between the two groups of girls to be somewhat erratic (as shown by the distribution of negative and positive differences in weight) while those of the two groups of boys conform more nearly to the size relationships of the large group of bulletin 266. An interesting observation in connection with data tabulated in Table 6 is that the highest percentages of low indices are found at age 11 for all groups except the country boys who have equal percentages of low scores at 10 and at 12 years.

TABLE 6

PERCENTAGES OF 137 CACHE COUNTY AND 136 LOGAN CITY SCHOOL CHILDREN HAVING THREE NUTRITIONAL INDICES IN LOW LEVEES (AGES 8 TO 12 YEARS)

Group	Total no. in group	Percentage in lower 29 percent (three indices 50 or lower)	Percentage in lower 15 percent (three indices 46 or lower)	Percentage in lower 9 percent (three indices 44 or lower)	Age at which highest percentage of 3 low indices occurred
Boys					
Cache County	68	26.5	13.2	7.3	10 and 12 yrs.
Logan City	79	30.4	13.9	8.9	11 yrs.
Girls					
Cache County	69	13.0	7.2	5.8	11 yrs.
Logan City	57	22.8	14.0	10.5	11 yrs.

In segregating those children having three indices below certain levels (all under 50) it was observed that a considerable number barely escaped falling into this class by having one score above 50, while the other two were lower. In some cases the one score was barely over 50, in other cases running as high as 80. Table 7 shows how the two low scores are distributed. Again the smallest relative number of low scores is seen to be that of the country girls, 18.8 per cent of them having two low scores (50 or less) as compared with 24.6 per cent of the city girls, 25.0 per cent of the country boys, and 30.4 per cent of the city boys.

The relatively fewer low scores of country children, particularly of the girls, is not in harmony with their appearance as observed by the investigators to whom the country children in general appeared less well nourished than did the city children. This may be accounted for in part at least by the fact that the country girls' greatest number of low indices were subcutaneous tissue indices, and that both they and the country boys had higher percentages of low musculature indices than did the city groups. This condition would tend to make their skeletal structures appear more prominent and thus give the impression of undernourishment.

Another method of determining the comparative nutritional status of children by means of their nutritional indices is provided by the Child Health Association. It consists of determining, by means of a special table, the number of children in a similar group of 1000 who would have indices lower than any given index. For example, a child having an index of 30 would, in a group of 1000, be number 24; that is, only 23 children in the group would have lower indices; an index of 50 would indicate 500 in 1000 with smaller indices. Table 8 is constructed to show the number and percentage of each group having indices of 50 or more, thus placing them on a level at which 500 out of 1000 would have smaller corresponding indices. The figures of this table suggest, as has been noted in connection with Table 6, that the nutritional status of country girls may be superior to that of the others. The percentage of their indices that are above 50 (column 7, Table 8) is noticeably higher than that of any other group. City girls are second highest in this classification, city boys third, and country boys lowest.

It would appear from the examination of indices so far that there is a greater difference in nutritional status on the basis of sex than on the basis of city or country residence.

As a further test of the relationships expressed by these indices they were submitted to analysis by the method of variance. The only significant differences (F values above the 5 per cent level) found on the basis of town and country residence are those for weight indices, and there the significance is not high the probability being only 19 to 1. The greater mean indices are those for country children. The same relationship is reflected in the distribution of low weight indices in Table 7, and in the relatively low percentages of high weight indices for city children in Table 8.

Substantiating the suggestion that sex may be a larger factor than residence in determination of indices, the variance analysis showed significant differences (F values above the 5 per cent level) on the

TABLE 7

DISTRIBUTION OF NUTRITIONAL INDICES OF 50 OR LESS FOR 137 CACHE COUNTY AND 136 LOGAN CITY SCHOOL CHILDREN (AGES 8 TO 12 YEARS)

No. having two indices of 50 or less	Cache County boys		Logan City boys		Cache County girls		Logan City girls	
	17		24		13		14	
Percentage of total no.	25.0		30.4		18.8		24.6	
Indices-	No. indices 50 or less	Percentage of total no. low indices	No. indices 50 or less	Percentage of total no. low indices	No. indices 50 or less	Percentage of total no. low indices	No. indices 50 or less	Percentage of total no. low indices
Musculature	7	20.6	8	16.7	5	19.2	4	14.3
Subcutaneous tissue	11	32.3	16	33.3	12	46.2	10	35.7
Weight	16	47.1	24	50.0	9	34.6	14	50.0
Totals	34	100.0	48	100.0	26	100.0	28	100.0

TABLE 8

NUMBER AND PERCENTAGES OF 137 CACHE COUNTY AND OF 136 LOGAN CITY SCHOOL CHILDREN HAVING NUTRITIONAL STATUS INDICES OF 50 OR MORE (AGES 8 TO 12 YEARS)

Indices	Indices of 50 or more, indicating 500 in 1000 with lower indices							
	Boys				Girls			
	Cache County		Logan City		Cache County		Logan City	
	number	percentage	number	percentage	number	percentage	number	percentage
Musculature	39	57.3	51	64.5	55	79.7	40	70.2
Subcutaneous tissue	25	36.8	32	40.5	36	52.2	27	47.4
Weight	28	41.2	26	32.9	44	63.8	25	43.8

basis of sex for weight indices within the city school and in one of the country schools, which in this connection may be designated school no. 1.

Significant differences in indices on the basis of age were found distributed as follows:

For musculature - in the city school and in country school no. 1.

For subcutaneous tissue - in the city school and in country school no. 2.

For weight - in the city school and in country school no. 1.

DISCUSSION AND CONCLUSIONS

Nutritional status indices developed by the Child Health Association procedure would suggest that the differences in size (height and weight measurements) of country and city children cannot be attributed to recent nutrition. That is, the relationship of soft tissue to skeletal structure is at least as good for the smaller children (country) as for the larger children (city).

If the part played by nutrition in the relative size of children is to be investigated, it would appear that some means must be found of measuring the effects of various types of nutrition, and also lengths of time such nutrition is in effect, upon the entire body, size and quality of skeletal tissue, and of the various soft tissues, as well as relationships between the two.

The present study suggests that the country children may have been subjected to a poorer grade of nutrition over a long period of time which has resulted in smaller bodies, but without disturbing in a marked degree the relationship between soft and hard tissues.

Jenss and Souther[7] tested the indices under discussion here, along with three others, each widely used, by comparison with their own procedures in their study of 713 New Haven school children. The following is quoted from these authors: "The indices have been tested when the child was 7 years by comparison with five criteria, which involve clinical judgment of nutritional status, need of medical and dental care, and an estimate of the child's gain in weight, and change in arm

[7] *Jenss, R. M. and Souther, S. P. Methods of assessing the physical fitness of children. U. S. Children's Bur. Pub. No. 263. 1940.*

girth. These criteria have been based on observations made of the children at both 6 and 7 years of age and on periodic weighings made at frequent intervals during a 19- or 20-month period of observation." After such comparison these authors conclude: "The indices are neither selective nor sensitive as they fail to identify a considerable number of boys or girls whom a given criterion selects as likely to be in need of medical care or nutritional advice and assistance, and, in addition, they often identify children who are not selected by the criterion."

As indicated earlier in this paper these quotations are in harmony with the opinions of the investigators to the effect that the derived nutritional status indices of various children who appeared undersized and poorly nourished gave them fair or good rating on the basis of number in 1,000 having smaller indices. The authors feel justified therefore in assuming that nutritional status indices developed in accordance with the Child Health Association monograph do not identify with definiteness the nutritional status of children in this study and do not therefore answer the question as to why Utah city school children are taller and weigh more at a given age than do children in country schools.

The authors gratefully acknowledge the assistance of Miss Sybil L. Smith of the office of Experiment Stations and of Dr. Rachel M. Jenss of the Children's Bureau, who read the manuscript and gave constructive criticism.

APPENDIX

Table 1, showing relative size of Cache County and Logan City school children. (See page 111)

Form 1, showing measurements taken on 137 Cache County and 136 Logan City school children from which nutritional indices were computed as indicated in lower half of the form. (See page 112)

How the Indices are Developed

On the upper one-half of Form 1 are recorded the measurements for a 10-year-old boy, Val. W. By referring these measurements to corresponding tables, one for each measurement (in Nutritional status indices, published by Am. Child Health Assoc., 1935, pages 42 to 47, inclusive), his nutritional indices may be determined. A summarization of the various steps taken follows:

1. Arm girth 38.5, table value 98.3 entered opposite "measure", under arm girth, lower one-half of form 1.
2. Subcutaneous tissue, 21.5, table value, 56.7, entered on form.
3. Weight 65, table reading 145.0, entered on form.
4. Height 53, table values for arm girth, subcutaneous tissue and weight, are 10.6, 17.5 and -24.4, respectively, entered on form.
5. Chest breadth 42.7, table readings, as under No. 4, -22.9, -9.7 and -29.1; entered on form.
6. Chest depth, 32.6, table values, as under No. 4, -19.6,-13.5, and -24.1, entered on form.
7. Hip width 24.0, table values, -20.1, -12.8, and -29.6; entered on form.

Since these table values are general for all boys from 10 to 12 years, inclusive, and fit only the middle age, 11 years, corrections must be made for the 10 and 12 year-olds. From a special table the corrections for 10-year-old Val. W. are found to be -1.0, -2.5, and -1.0, entered on the form.

Adding columns and combining corresponding positive and negative values results in the three indices 45.3 for musculature as indicated by arm girth, 35.7 for subcutaneous tissue, and 36.8 for weight. By means of another table it is found that among a sampling of 1,000 boys of the same age and general build as Val. W., 309 would have poorer musculature; 67 would have less subcutaneous tissue, and 81 would weigh less. All of which would place Val. W. in the lower 15 per cent of his group in musculature, and the lower 9 per cent with respect to subcutaneous tissue and weight.

TABLE 1

(APPENDIX) MEAN HEIGHTS AND WEIGHTS OF LOGAN CITY SCHOOL CHILDREN COMPARED WITH SIMILAR MEASURMENTS OF CACHE COUNTY CHIIDREN OUTSIDE OF LOGAN (TOTAL ELEMENTARY SCHOOL POPULATION)*

	BOYS						GIRLS					
Age years	Mean heights (inches)		Excess city over county	Mean weights (lbs.)		Excess city over county	Mean heights (inches)		Excess city over county	Mean weights (lbs.)		Excess city over county
	Logan	Cache Co.		Logan	Cache Co.		Logan	Cache Co.		Logan	Cache Co.	
6	46.2	45.0	1.2	48.2	45.9	2.3	46.0	44.1	1.9	47.5	43.0	4.6
7	47.2	46.2	1.0	52.0	49.6	2.4	46.9	46.6	0.3	49.4	47.7	2.7
8	49.4	48.6	0.8	56.8	54.5	2.3	49.4	48.6	0.8	55.2	53.1	2.1
9	51.6	50.7	0.9	61.7	60.6	1.1	51.6	50.3	1.3	61.0	57.9	3.1
10	53.5	52.7	0.8	68.5	66.8	1.7	53.7	52.5	1.2	65.7	64.4	1.3
11	55.5	54.2	1.3	74.7	72.3	2.4	55.7	54.5	1.2	74.7	70.4	4.3
12	57.8	55.6	2.2	82.4	76.7	5.7	58.8	56.1	2.7	86.3	76.0	10.3
13	60.0	58.0	2.0	91.9	87.2	4.7	60.7	58.9	1.8	96.8	87.0	9.8
14	61.8	59.6	2.2	100.7	94.3	6.4	61.3	61.1	0.2	101.7	97.5	4.2

* These measurements were taken two years earlier than were those which form the basis of the present report, hence some of the children involved were included in both studies.

SCORE CARD FOR

NUTRITIONAL STATUS INDICES

Name Val. W. Sex Boy Age 10 Date of Birth 7/28/27

School Whittier Grade 4 Date 3/19/37

MEASUREMENTS

1. Arm girth: Flexed a 19.5 Relaxed b 19 c (a + b) 38.5
2. Subcutaneous tissue over biceps: d 10.5 e 11 f (d + e) 21.5
3. Weight g 65.0
4. Height h 53.0
5. Chest breadth: Expiration i 21.2 Inspiration j 21.5 k (i + j) 42.7
6. Chest depth: Expiration l 16.1 Inspiration m 16.5 n (l + m) 32.6
7. Width of Hips o 24.0

COMPUTATION OF INDICES

	Arm girth		Subcutaneous tissue		Weight	
	+Value	-Value	+Value	-Value	+Value	-Value
Measure	98.3		56.7		145.0	
Height	10.6		17.5			24.4
Chest breadth		22.9		9.7		29.1
Chest depth		19.6		13.5		24.1
Hip width		20.1		12.8		29.6
Adj. for age		1.0		2.5		1.0
Sums	108.9	63.6	74.2	38.5	145.0	108.2
Indices	45.3		35.7		36.8	
Number in 1000 with smaller indices	309		67		81	

DATA ON ERUPTION AND CARIES OF THE DECIDUOUS TEETH

CARL R. DOERING AND MARGARET F. ALLEN[1]

INTRODUCTION

The study of growth and development made by the Department of Child Hygiene at the Harvard School of Public Health[2] includes data on the eruption and the carious condition of the deciduous teeth which deserve preliminary statistical analysis. The babies studied were born to mothers who had attended the out-patient department of a maternity hospital for prenatal care. They are considered to be a representative sample of a middle class population. The families are for the most part of Northern European stock. A detailed description of the group is given in another publication (8, p. 20). The children were examined at birth, at three months' intervals up to one year, and at six months' intervals thereafter. There have been few changes in the personnel examining the children.

PART I. ERUPTION

The presence or absence of a tooth was determined by the pediatrician at the physical examination. After the child's third birthday a dentist examined the mouth and the findings were recorded on dental charts. A tooth was considered erupted if it had ruptured the membrane of the gum and was in sight. No attempt was made to rate the degree of eruption of any tooth (2, p. 25). Because it is known that the female (6 and 2, p. 54) tends to erupt the permanent teeth at an age earlier than the male, the two sexes have been tabulated separately in order to see if a similar sex difference holds with respect to deciduous teeth. Like teeth in the same jaw have been considered independently.

Description of Tables

Table 1 gives the number of teeth present in the mouth at the various ages. (As this is a study of children brought into the group by birth, there were new cases added as time progressed. Some of the children were dropped from the group. For these two reasons, the number of children examined at successive ages decreases.) No tooth in any child had erupted at three months of age. The limits of variation in the age at examination were prescribed as follows:

6	through	24	months	7	days
30	"	54	"	10	"
60	"	72	"	14	"
78	"	and over		21	"

The distributions are irregular and show that the deciduous teeth tend to erupt in pairs. An examination of the lateral incisors at one year,

[1] *Department of Vital Statistics, Harvard School of Public Health.*

[2] *The Center for Research in Child Health and Development at the Harvard School of Public Health is under the direction of Dr. Harold C. Stuart. The dental examinations used as a basis for this paper were made by Dr. F. C. Allen, Dr. Philip Williams and Dr. J. Murray Gavel of the Forsythe Dental Infirmary.*

TABLE 1

NUMBER OF TEETH ERUPTED

Teeth	Age in Months						
	Males						
	6	9	12	18	24	30	36
0	98	23	2				
1	8	4	1				
2	19	31	7				
3		7	3				
4	2	25	13				
5		7	12	2			
6		23	43	1			
7		6	14	4			
8		5	33	10			
9			2	2			
10				8			
11			1	4	1		
12				43	7		
13				1			
14				7	2		
15				3	2		
16				31	66	12	2
17						6	1
18					7	8	1
19				1	2	3	
20				1	26	81	103
Children	127	131	131	118	113	110	107
Mean	0.43	3.37	5.99	12.48	16.75	19.23	19.88
σ	0.86	2.34	1.93	3.03	2.20	1.40	0.64
σ_{mean}	0.08	0.21	0.17	0.28	0.21	0.13	0.06
	Females						
0	118	30	2				
1	6	10	2				
2	17	37	14				
3	1	4	5				
4		25	21	2			
5	1	2	14				
6		11	34	1			
7		4	12	1			
8		9	26	10			
9			2	3			
10			4	8			
11				4			
12			1	45	9	1	
13				3	1		
14				18	5	1	
15				2	2		
16				26	55	14	1
17					5	3	
18					11	10	3
19						6	
20					24	78	107
Children	143	132	137	123	112	113	111
Mean	0.34	2.82	5.58	12.43	16.64	19.07	19.91
σ	0.80	2.41	2.26	2.70	2.24	1.63	0.49
σ_{mean}	0.07	0.21	0.19	0.24	0.21	0.15	0.05

showed that 15 females or 11 per cent had one or the other of the upper laterals; 17 females or 12 per cent had but one of the lower laterals; 12 or 9 per cent of the males had one upper lateral; and 18 or 14 per cent had one lower lateral. In no other tooth at any age were these differences found. This and other evidence from the records indicates that on the average there is no great difference in time of eruption of like teeth in the same jaw; examinations at shorter intervals would be necessary in order to observe this difference. At 6 months of age approximately one-fourth of males and approximately one-sixth of females have at least one tooth erupted. At 36 months of age only 4 out of 107 males and 4 out of 111 females failed to have all their teeth. On the average males have more teeth than females at every age except at 3 years. These differences are small and although not significant statistically are nevertheless consistent. At 18 months of age the variation in the number of teeth present is greatest; in males one out of 118 had all teeth erupted and two had only 5 teeth. In females 26 out of 123 had 16 teeth and two had only 4. Judging from the differences of the average number of teeth present at the various ages, one notices that more teeth erupt between the ages of 12 and 18 months than at any other time.

Table 2 gives the percentage of children with each type of deciduous tooth present at the various ages. It is noticeable that the teeth are approximately divided into two groups with respect to time of eruption in both sexes and in both jaws - namely, the early erupting teeth, the incisors, and the late erupting teeth, the molars and the cuspids. However there are some minor differences between the sexes and the jaws. In both sexes at the earlier ages there are present more mandibular than maxillary central incisors and more maxillary than mandibular lateral incisors. Between the sexes, at 9 months of age, there is a statistically significant difference in the number of maxillary central incisors present and at 12 months of age in the number of maxillary lateral incisors present; in both cases males have the greater number. In general the deciduous teeth erupt in the following order:.central incisors, lateral incisors, first molars, cuspids, and second molars. This table shows very well that like teeth in the same jaw erupt about the same time, an observation previously made.

From the original records it was noticed that in 13 males and in 14 females out of approximately 110 males and 110 females, certain discrepancies in order of eruption occurred. Most frequently in this small group the lower lateral incisors erupted after the first molars and at times the cuspids appeared before the first molars. Occasionally all the mandibular teeth were present when there were no maxillary cuspids or second molars present. Two males never erupted 20 teeth; one did not have either of the upper lateral incisors, the other lacked the lower left lateral incisor. These two children have not been included in the study.

Ledé (5), Chérot (3), and Boas (1) have studied groups of children to determine the ages at which the different teeth erupt. Ledé, whose group of children may have had repeated examinations, found that the lower central incisors erupted first and that the upper lateral incisors erupted before the lower ones except in his group of artificially fed infants. He also observed that the upper first molars and cuspids

TABLE 2

PERCENTAGE OF CHILDREN WITH EACH TYPE OF DECIDUOUS TOOTH PRESENT

Tooth	Age in Months						
	Males						
	6	9	12	18	24	30	36
Upper Right Sec.Molar				1.7	26.5	77.3	96.3
First Molar			0.8	79.7	100.0	100.0	100.0
Cuspid			0.8	35.6	92.9	100.0	100.0
Lateral Incisor		28.2	70.2	96.6	100.0	100.0	100.0
Central Insisor	1.6	54.2	90.8	100.0	100.0	100.0	100.0
Upper Left Cen. Incisor	1.6	55.0	92.4	100.0	100.0	100.0	100.0
Lateral Incisor		28.2	74.8	99.2	100.0	100.0	100.0
Cuspid			0.8	35.6	92.0	100.0	100.0
First molar			0.8	82.2	100.0	100.0	100.0
Second Molar				1.7	25.7	77.3	96.3
Lower Right Sec. Molar				2.5	29.2	84.5	97.2
First Molar				78.8	100.0	100.0	100.0
Cuspid				32.2	90.3	100.0	100.0
Lateral Incisor		6.9	33.6	94.9	99.1	100.0	100.0
Central Incisor	18.1	77.1	96.9	100.0	100.0	100.0	100.0
Lower Left " "	21.3	78.6	98.5	100.0	100.0	100.0	100.0
Lateral Incisor		9.2	36.6	94.1	99.1	100.0	100.0
Cuspid			0.8	31.4	91.2	100.0	100.0
First Molar			1.5	79.7	100.0	100.0	100.0
Second Molar				2.5	29.2	83.6	98.1
None	77.2	17.6	1.5				
Children	127	131	131	118	113	110	107
	Females						
Upper Right Sec.Molar				0.8	26.8	77.9	96.4
First Molar			2.9	83.7	100.0	100.0	100.0
Cuspid			0.7	33.3	88.4	97.3	100.0
Lateral Incisor	0.7	18.9	56.2	95.9	100.0	100.0	100.0
Central Incisor	0.7	40.9	85.4	100.0	100.0	100.0	100.0
Upper Left Cen. "	0.7	40.9	85.4	100.0	100.0	100.0	100.0
Lateral Incisor		18.2	61.3	95.1	100.0	100.0	100.0
Cuspid				35.0	87.5	98.2	100.0
First molar			3.6	84.6	100.0	100.0	100.0
Second molar				0.8	25.9	77.0	96.4
Lower Right Sec.Molar				0.8	28.6	77.9	99.1
First Molar			2.2	82.1	100.0	100.0	100.0
Cuspid				28.5	88.4	99.1	100.0
Lateral Incisor		9.1	30.7	95.1	100.0	100.0	100.0
Central Incisor	14.7	72.0	97.1	100.0	100.0	100.0	100.0
Lower Left " "	16.1	73.5	95.6	100.0	100.0	100.0	100.0
Lateral Incisor	0.7	9.1	34.3	94.3	100.0	100.0	100.0
Cuspid				28.5	88.4	99.1	100.0
First Molar			2.9	83.7	100.0	100.0	100.0
Second Molar				0.8	30.4	80.5	99.1
None	82.5	22.7	1.5				
Children	143	132	137	123	112	113	111

erupted before the lower ones. Chérot, who apparently examined his group of children only once, also has results for the lateral incisors which agree with those from this group. He gives the upper central incisors, however, as erupting before the lower ones. At 12 months the Harvard group had significantly more lower central incisors and at 24 months significantly fewer second molars, both upper and lower, than the Chérot group. In view of the fact that these series of observations may have been collected on quite different bases, these comparisons probably should not be taken too seriously. When these data were compared with those of Boas which were collected in an institution, it appeared that the children examined by Boas erupted their teeth at a later age than those in this group although the numbers were small and the sampling errors large.

Table 3 shows the percentage of children in whom a specified type of deciduous tooth erupted during the period immediately preceding the examination. Some information about the age at eruption may be summarized roughly in the following form:

1. Upper central incisors erupt between 6 and 12 months in 88 per cent of the children.
2. Lower central incisors erupt between 6 and 12 months in 80 per cent of the children.
3. Upper lateral incisors erupt between 6 and 12 months in 66 per cent of the children.
4. Lower lateral incisors erupt between 12 and 18 months in 61 per cent of the children.
5. First molars erupt between 12 and 18 months in 81 per cent of the children.
6. Cuspids erupt between 18 and 24 months in 58 per cent of the children.
7. Second molars erupt between 24 and 30 months in 54 per cent of the children.

The tooth with the greatest variation in age of eruption is the second molar. One child may have this tooth at 18 months, but another may not have it at 3 years.

Palmer, Klein and Kramer (6) show that the age distribution of eruption of the permanent teeth is well described by the normal probability curve. In the Harvard Group the percentages having both the right and left specified deciduous tooth were plotted by jaw and by sex. The lines tended to be curved.

Table 4 gives the percentages of children who had both the right and left tooth of a specific type. These percentages correspond roughly with those made by Palmer, Klein and Kramer. However, for a better description, the age interval should have been smaller.

If the percentages at each age were allowed to vary by twice the chance variation, straight lines could have been drawn in, but in view of the fact that the same children may be included at successive examinations this is a dubious procedure since the chance variation as computed assumes independence of the observations (9). All of the lines curved in the same direction. The age distributions of males and females were more similar in the lower than in the upper jaw. The greatest difference between the sexes with respect to eruption was in

TABLE 3

PERCENTAGE OF CHILDREN WHO ERUPTED THE SPECIFIED TOOTH DURING THE PRECEDING PERIOD

	Age in Months							
	Males							
Tooth	6	9	12	18	24	30	36	42
Upper Right Second Molar				1.7	23.4	51.9	19.6	4.3
First Molar			0.8	79.5	19.6			
Cuspid			0.8	35.0	57.0	7.5		
Lateral Incisor		28.7	41.3	27.4	3.7			
Central Incisor	1.6	51.6	38.1	9.4				
Upper Left Central Incisor	1.6	54.1	37.3	7.7				
Lateral Incisor		29.5	45.2	26.5	0.9			
Cuspid			0.8	35.0	57.9	8.5		
First molar			0.8	82.1	16.8			
Second Molar				1.7	22.4	52.8	18.6	4.3
Lower Right Second Molar				2.6	25.2	56.6	12.7	2.2
First Molar				80.3	18.7			
Cuspid				32.5	57.9	10.4		
Lateral Incisor		7.4	27.0	61.5	4.7	0.9		
Central Incisor	18.1	59.0	19.8	3.4				
Lower Left Central Incisor	21.3	57.4	19.8	1.7				
Lateral Incisor		9.8	27.8	57.3	8.4	0.9		
Cuspid			0.8	30.8	59.8	9.4		
First Molar			1.6	79.5	18.7			
Second Molar				2.6	25.2	55.7	13.7	2.2
Children	127	122	126	117	107	106	102	93
	Females							
Upper Right Second Molar				0.8	26.2	53.8	20.6	4.1
First Molar			3.1	81.7	15.5			
Cuspid			0.8	31.7	56.3	9.6	2.9	
Lateral Incisor	0.7	18.5	38.8	40.0	3.9			
Central Incisor	0.7	40.0	45.7	13.3				
Upper Left Central Incisor	0.7	40.0	44.2	15.0				
Lateral Incisor		18.5	45.0	35.8	4.9			
Cuspid				34.2	54.4	10.6	2.9	
First molar			3.9	81.7	15.5			
Second molar				0.8	25.2	52.9	18.6	4.1
Lower Right Second Molar				0.8	31.1	51.0	18.6	1.0
First Molar			2.3	80.8	17.5			
Cuspid				28.3	61.2	11.5	1.0	
Lateral Incisor		10.0	20.2	65.0	3.9			
Central Incisor	14.7	56.9	26.4	2.5				
Lower Left Central Incisor	16.1	57.7	22.5	5.0				
Lateral Incisor	0.7	8.5	24.0	60.8	4.9			
Cuspid				28.3	60.2	11.5	1.0	
First Molar			3.1	81.7	16.5			
Second Molar				0.8	30.1	53.8	17.6	1.0
Children	143	130	129	120	103	104	102	97

TABLE 4

	6	9	12	18	24	30	36
Male							
Upper							
C. I.	1.6	51.9	90.1	100	100	100	100
L. I.		26.0	67.9	95.8	100	100	100
Cuspids			0.8	34.7	91.2	100	100
1st Molars			0.8	79.7	100	100	100
2nd Molars				1.7	25.7	74.5	95.3
Lower							
C. I.	16.5	74.8	96.9	100	100	100	100
L. I.		4.6	28.2	91.5	99.1	100	100
Cuspids				30.5	89.4	100	100
1st Molars				78.0	100	100	100
2nd Molars				2.5	28.3	81.8	97.2
Female							
Upper							
C. I.	0.7	40.2	83.2	100	100	100	100
L. I.		14.4	53.3	94.3	100	100	100
Cuspids				33.3	87.5	97.3	100
1st Molars			2.9	82.1	100	100	100
2nd Molars				0.8	25.0	75.2	96.4
Lower							
C. I.	13.3	68.2	94.9	100	100	100	100
L. I.		7.6	26.3	92.7	100	100	100
Cuspids				26.8	88.4	99.1	100
1st Molars			2.2	81.3	100	100	100
2nd Molars				0.8	27.7	77.7	99.1

the upper lateral incisors, a difference which has been pointed out before.

Correlations

One may ask if a child who erupts his first tooth at an early age will erupt the rest of his teeth correspondingly early. A high negative correlation was obtained between the number of teeth present at 9 months and the number of teeth erupted between 9 and 24 months. This result is forced by the fact that a child who has no teeth at 9 months can erupt 20 teeth between 9 and 24 months whereas a child with 8 teeth at 9 months can erupt but 12 teeth between 9 and 24 months.

When the number of teeth which erupted between 9 and 24 months divided by the number which could have erupted during this period was correlated with the number of teeth present at 9 months, the correlation coefficient was found to be .19 for males and .44 for females. When the number of teeth present at 18 months was correlated with the number erupted between 18 and 24 months divided by those which could have erupted in that period, there was a correlation of .24 for males and .33 for females. The correlation of .19 is the only one which is not statistically significant.

Another and simpler way of answering the question is to correlate the age at which the first tooth was present with the age at which the last tooth was present. The data are shown in Table 5. The correlations were .30 for males and .56 for females, higher correlations than were obtained by either of the other ways of handling the data. They are significantly different from one another. It can be concluded that the process of dentition takes place at an earlier age in some children than in others.

TABLE 5

Age when first tooth was present (in months)	Age when last tooth was present (in months)										
	Males						Females				
	18	24	30	36	42	Total	24	30	36	42	Total
6		7	14	4		25	9	9			18
9	1	14	34	12		61	14	31	12	1	58
12		1	5	6	1	13		8	12	1	21
15*					1	1				2	2
Children	1	22	53	22	2	100	23	48	24	4	99

*Fifteen months was used because all children examined at 15 months had at least one tooth.

One may ask if in the early erupting group the process of dentition takes place more rapidly than in the late erupting group or if there is evidence of a converse relation. With a little manipulation of Table 5 it was found that, in boys, the rapidity of dentition tended to be greater among the late erupting group and in girls tended to be greater among the earlier erupting group. The slight relationships are not statistically significant. This does not mean that the rapididity of dentition is constant for all children; indeed there is considerable variation. The distribution is given in Table 6. For males the mean is

TABLE 6

Months	Period during which total dentition took place*									
	12	15	18	21	24	27	30	33	36	Total
Males	1	1	14	12	34	20	13	5		100
Females			14	17	31	21	14	1	1	99
Total	1	1	28	29	65	41	27	6	1	199

*Due to the nature of the records the periods are all over-estimated. The true period for every child is always less than that given in the table; consequently the means given are greater than the true means.

24.4 months, the standard deviation 4.32 months; for females the mean is 24.3 months, the standard deviation 3.98 months. The extremes of these distributions should be useful for further studies, perhaps particularly with regard to the development of the maxilla and the mandible.

Suspecting that the boy who erupted 20 teeth in less than 12 months before he was 18 months old might be an observation due to an error in tabulation, we referred again to the case history and found the datum to

be correct. Incidentally at his latest examination (10 years) the boy is the tallest in the study group, well-proportioned and outstanding in other characteristics - a splendid specimen.

Age Index of Eruption

It is expected that a future paper from the Department of Child Hygiene will discuss tooth eruption in relation to other phases of growth. For this reason it is desirable to have an index of the age of tooth eruption. The above results suggest that the age at which the first tooth appears is one such figure. A more stable index would involve all the teeth. Such a measure was computed by giving to the number of teeth erupted between examinations, weights which varied with the age of examination. The number present at 6 months was given a weight of -4; the teeth erupted between 6 and 9 months were given a weight of -3, etc. These weights were made proportional to the age period involved and were centered about 18 months in such a way as to make the average index approximately 0. An example of the computation of the index is given in Table 7.

TABLE 7

Examination	6	9	12	18	24	30	36	42	Total
Weights	-4	-3	- 2	0	2	4	6	8	
Number of new teeth	0	0	4	6	6	0	4	0	20
WeightsXteeth	0	0	- 8	0	12	0	24	0	28

The sum of the row, weightsXteeth, with regard to sign, is 28. Dividing 28 by 20, the number of teeth, gives an index of 1.4.

The average age at eruption cannot be found because the records show only that the tooth has or has not erupted at the standard ages at which the child was examined. This, however, would be likely to be the case in any growth study. The age-index would be the average age of eruption referred to an origin at 18 months and with a unit of 3 months if the teeth erupted on the date of the examination. If one were willing to assume that the teeth erupted at the mid-age between examinations one would use different weights as is shown in Table 8.

TABLE 8

Examination	6	9	12	18	24	30	36	42	Total
Weights	-4½	-3½	-2½	-1	1	3	5	7	
Number new teeth	0	0	4	6	6	0	4	0	20
WeightsXteeth	0	0	-10	-6	6	0	20	0	10

This gives an index of 0.5 referred to age 18 months as origin and shows that the average age of eruption on this assumption was $18+0.5\times3 = 19.5$ months. A study of the facts did not seem to make it advantageous to make the assumption in comparison with simply basing the index directly upon the new teeth present at each examination.

The index is available for every child who was examined at all the specified ages. At the time these data were taken from the records there were 92 males and 89 females who fulfilled these conditions. The frequency distribution of the indices is given in Table 9.

TABLE 9

Indices	Males	Females
-1.55 thru -1.25	1	
-1.20 " - .90	2	5
- .85 " - .55	5	8
- .50 " - .20	13	9
- .15 " .15	23	10
.20 " .50	17	15
.55 " .85	12	16
.90 " 1.20	9	11
1.25 " 1.55	3	6
1.60 " 1.90	3	3
1.95 " 2.25	2	2
2.30 " 2.60	2	
2.65 " 2.95		3
3.00 " 3.30		1
Children	92	89

There is a considerable amount of spread in the distribution. This makes the index useful for correlation purposes. The average index for males is .335 and the standard deviation of the distribution is .749. For females the average is .489 and the standard deviation is .914. The difference between the means is not statistically significant, although the percentages in Tables 2 and 3 seem to indicate that certain teeth erupt earlier in males than in females.

There were 27 families in which there were siblings for whom an index could be computed. An intraclass correlation coefficient of .53 was obtained for the 27 pairs. This is a high value for a coefficient of this type. It is of the order of magnitude of those for fraternal inheritance of physical characters (stature, eye-color, etc.) quoted from Pearson by Pearl (7, p.175).

PART II. CARIES

The data on caries are limited and more fragmentary than on eruption. Of the various reasons for this the principal one was that regular examinations by dentists were not instituted until the fifth year of the study. The pediatricians were not qualified to detect minute cavities in the teeth although they could be relied upon to notice the presence or absence of a tooth. Although detailed information on caries was recorded by the dentists which will be analyzed by them later, only gross information was used in this preliminary descriptive analysis.

A tooth has been considered defective if cavitation with debris or fillings were present. No attention has been given to either the size or number of caries in a given tooth. If a tooth is missing and known to be defective before extraction it is included in this study.

Description of Tables

Table 10 shows the number of defective teeth at each age. Even at 3 years not all of the children had perfect mouths. There were two females with lower second molars that erupted between 2 and 2½ years and were found defective at age 2½ years. There were two males, one with two upper second molars defective at age 2½ years, the other with one upper second molar defective at age 3 years, in whom the three teeth were less than 6 months of age. At 7½ years, none of the females and at 8½ years only one of the males had no carious teeth.

It should be recalled that when teeth were extracted because of their carious condition they were carried forward as carious teeth in Tables 10 and 11. If they were lost naturally and were not carious they were carried forward as sound teeth. In Table 11 the percentages given for each type of tooth are the averages of the percentages for the right and left side of the jaw.

The females have more defective teeth on the average through 4½ years, but after this age there is nothing consistent in the behavior of the means. The differences in the means between the sexes in the number of defective teeth at the various ages are not statistically significant except at 3 years. If the percentages of mouths without defect are considered, then the males seem to have better mouths since it is only at 5 years that the females have a higher percentage of perfect mouths.

Seeming impossibilities such as listing fewer defective teeth at 6½ years than at 6 years occur because some children with poor mouths were not examined at 6½ years. To see if there was any consistency in the type of mouth which missed examinations, the data were tabulated in the following manner. All males examined at 5 years were classified as to whether they were also examined at 4½ and at 5½ years, and the average number of defective teeth at 5 years was computed for each of the groups. The average for all four groups was 4.06 carious teeth at 5 years. The results are shown in Table 12. In this particular group the children examined all three times and the children examined only once had better mouths on the average at 5 years than the group as a whole. Several more age groups were examined in this manner and in each group different results were obtained. Children who missed examinations were not consistently different from the whole group.

Table 11 shows the percentage of children with carious teeth according to type of tooth. In spite of being the last tooth to erupt, the second molar becomes carious early and rapidly. The first molar also breaks down frequently, but not so early or to the same extent as the second molar. Like teeth on opposite sides of the jaw have been grouped since there was no apparent differences between them. The lower second molars in the female are more defective at every age than in the male; at some ages significantly different. The lower first molars of the female are more defective than those of the male through 4½ years. It is only in the lower incisors that the male seems to show higher percentages of caries than the female. When the lower and upper jaws are compared it can be seen that the molars of the lower jaw are found to be defective more frequently than those of the upper jaw. The upper incisors are defective more often than the lower incisors.

TABLE 10

NUMBER OF DECIDUOUS TEETH FOUND TO BE DEFECTIVE (PAST AND PRESENT)

Teeth	Age in Years																							
	Males												Females											
	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½
0	33	28	28	24	13	15	10	6	4	3	2	1	30	26	20	19	17	12	5	5	1			
1	2	3	5	7	5	6	4	4	5	4	2		2	5	4	3	5	4	6	3	1	2	1	
2	1	2	4	7	10	5	6	3	3	3	6	3	5	7	7	6	11	8	4	6	6	3		1
3	1	2	3	7	8	7	2	4	1				1	2	3	7	4	5	6	7	3	2	1	
4			2	6	8	5	11	10	4	4	3		1	4	5	2	8	11	7	6	5	5	4	1
5		1	2	3	4	2	2		3	1	2	1		3	2	2	3	2	2	7	5	5	2	2
6			2		2	5	3	4	2	2	1	2	2	1	5	6	3	6	4	3	2	5	3	5
7			1	4	3	2	5	7	5		2	2		1		2	6	6	1		1	2	3	2
8		1	2	2	3	5	6	5	5	6	4	2		2		1	1	3	5	3	5	5	5	1
9		1	1	1	5	3	4	3	5	4	2	3			2	1	3	1	4	4	4	1	1	3
10		1			2	1	1	2	1	1						3	3	1	3		3	5	4	5
11			1		2	2	3				1	2						1	1	2	1	2	2	1
12				2	1	3	4	1	2	2	2	1						3	6	3	1	1		
13							1	5	4	4	1	2							1	2	4	3	3	1
14						1	1	1	2	3	1									1	1		2	2
15					1	2	2	3			1										1	1	1	1
16																								
17							1																	
18								1	1	1	1	1												
Children	37	38	51	63	67	64	66	59	47	38	31	20	41	51	50	52	64	63	55	52	44	42	32	25
Mean	0.19	0.95	1.86	2.51	4.06	4.53	5.73	6.37	6.57	7.18	6.48	7.90	0.76	1.67	2.38	2.90	3.30	4.08	5.51	5.21	6.73	6.90	8.19	8.48
Per cent with no defects	89.2	73.7	54.9	38.1	19.4	23.4	15.2	10.2	8.5	7.9	6.5	5.0	73.2	51.0	40.0	36.5	26.6	19.0	9.1	9.6	2.3	0.0	0.0	0.0
σ	0.61	2.20	2.82	2.99	3.60	4.27	4.45	4.61	4.52	4.87	4.74	4.35	1.52	2.26	2.63	3.08	3.06	3.32	3.95	3.88	3.96	3.57	3.53	3.25
σ_{mean}	0.10	0.36	0.40	0.38	0.44	0.54	0.55	0.61	0.66	0.80	0.86	0.99	0.24	0.32	0.38	0.43	0.39	0.42	0.54	0.55	0.60	0.56	0.63	0.66

TABLE 11

PERCENTAGE OF CHILDREN WITH DEFECTIVE DECIDUOUS TEETH ACCORDING TO TYPE OF TOOTH

Teeth	Age in Years																							
	Males												Females											
	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½
Upper Second Molars	6.8	11.8	32.4	38.1	48.5	50.0	63.6	70.3	72.3	72.4	69.4	80.0	3.7	24.5	37.0	35.6	39.1	53.2	55.5	53.8	63.6	70.2	81.2	78.0
First Molars		5.3	11.8	15.9	26.1	29.7	40.2	50.8	50.0	60.5	56.5	67.5		2.9	9.0	16.3	18.0	27.0	46.4	42.3	60.2	67.9	78.1	78.0
Cuspids			2.9	4.8	6.0	10.9	12.1	15.3	13.8	22.4	17.7	20.0				1.9	3.1	4.8	10.0	8.7	14.8	11.9	18.8	28.0
Lateral Incisors		1.3	2.0	3.2	8.2	8.6	12.9	16.9	17.0	21.1	11.3	12.5		3.9	2.0	1.9	3.9	4.8	12.7	13.5	21.6	20.2	25.0	22.0
Central Incisors		2.6	4.9	8.7	15.7	21.1	25.8	23.7	24.5	28.9	22.6	25.0		5.9	2.0	2.9	3.9	5.6	20.9	18.3	23.9	21.4	25.0	20.0
Lower Second Molars	2.7	21.1	27.5	38.9	59.0	59.4	65.9	67.8	73.4	69.7	67.7	85.0	20.7	31.4	44.0	54.8	60.2	65.9	73.6	72.1	80.7	78.6	81.2	88.0
First Molars		5.3	11.8	15.1	37.3	41.4	53.9	55.1	59.6	61.8	54.8	72.5	11.0	10.8	22.0	27.9	34.4	37.3	50.0	46.2	59.1	59.5	70.3	78.0
Cuspids				0.8	2.2	5.5	7.6	12.7	14.9	18.4	19.4	27.5	2.4	2.0	3.0	3.8	2.3	5.6	5.5	5.8	11.4	14.3	29.7	32.0
Lateral Incisors							3.0	3.4	2.1	2.6	3.2	2.5		1.0										
Central Incisors							1.5	2.5	1.1	1.3	1.6	2.5		1.0					0.9		1.1	1.2		
Children	37	38	51	63	67	64	66	59	47	38	31	20	41	51	50	52	64	63	55	52	44	42	32	25

TABLE 12

MEAN NUMBER OF DEFECTIVE TEETH OF MALES EXAMINED AT 5 YEARS
(The number in parentheses applies to children in each group)

	Examined at 4½	Not examined at 4½
Examined at 5½	3.46 (37)	6.58 (12)
Not examined at 5½	4.30 (10)	2.75 (8)

Relative Index of Carious Teeth

In order to relate caries to other variables it is desirable to have the history of the development of caries in the mouth of each child expressed in one figure.

Straight lines were fitted to the mean number of defective teeth (Table 10). The line was found to fit the data for females better than for males although a variance analysis indicated that the deviations from the lines were not statistically significant. Although differences seem to exist between the sexes for certain types of teeth, no good reason could be found for keeping them separate on the average number of defective teeth. Consequently the data have been combined (see Table 13). A straight line was fitted to these means, and a variance analysis was computed. The deviations from the trend line were not significant, but they were consistently positive at the beginning and end of the series. For this reason, a parabola, was fitted to the data with satisfactory results. The values for the straight line and parabolic fits are given in Table 14. The expected number of carious teeth as determined by the parabola will be used as a standard. For each child, provided it had at least five examinations, the differences between the number of its carious teeth and the expected number in the standard at each examination were summed with regard to sign and divided by the number of examinations. The index for one of the children is computed in Table 15. The sum of the deviations is -3.0 and as there were five

TABLE 13

	Carious teeth according to age											
	Age in years											
	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½
Mean	0.49	1.36	2.12	2.69	3.69	4.31	5.63	5.83	6.65	7.04	7.35	8.22
σ	1.22	2.27	2.74	3.04	3.24	3.72	4.24	4.32	4.26	4.23	4.26	3.79
σ_{mean}	0.14	0.24	0.27	0.28	0.28	0.33	0.39	0.41	0.45	0.48	0.54	0.57

examinations the index for this child is -.6. A negative index means that the child has fewer carious teeth than the standard (a better mouth) and a positive index means a worse mouth.

It has to be borne in mind that the index is of the simplest kind showing the average number of teeth defective above or below the stand-

TABLE 14

	Age in years											
	3	3½	4	4½	5	5½	6	6½	7	7½	8	8½
Straight Line	0.7	1.4	2.2	2.9	3.6	4.3	5.0	5.7	6.5	7.2	7.9	8.6
Parabola	0.4	1.3	2.1	3.0	3.7	4.5	5.2	5.9	6.5	7.1	7.6	8.1

TABLE 15

	Age in years							
	5	5½	6	6½	7	7½	8	8½
Standard	3.7	4.5	5.2	5.9	6.5	7.1	7.6	8.1
No. defective teeth	1	-	-	-	5	8	8	8
Deviations	-2.7				-1.5	.9	.4	-.1

ard. If records were adequate one could make a more elaborate and accurate estimate of defectiveness by counting the number of defects, but the additional elaborateness and accuracy might be largely elusory - at any rate one would have to be very careful of one's definitions to avoid misunderstandings in respect to both the recording of the observations and the interpretation of the index. If there were sufficient and sufficiently good data it would be interesting to apply the well-known actuarial life-table technique to discussing defectiveness, but this seemed inadvisable in the present instance. It may be noted that a relative index of age of eruption could have been used instead of the one we did use. It would only be necessary to set up a standard number of teeth present at each age and average for each child the departures from that standard as is done for the relative index of decay. If the records of decay at the different ages had been as continuous as were those of eruption it would have been possible to set up an index of decay like that of eruption.

Similar to the index for tooth eruption, there is a considerable amount of scatter in these indices. There were 72 males and 74 females who had had five or more dental examinations. Their indices form the frequency distribution given in Table 16. The range in the indices for males is from -5.7 to 10.2 and for females from -5.3 to 7.5. The means and standard deviations are -.18 and 3.55 respectively for males and -.03 and 3.15 for females. The difference between the means is not significant.

These indices were correlated with the eruption indices to test roughly the relationship between age of eruption of teeth and carious condition. The correlation coefficients are .14 for males and .04 for females and are not significant.

There are 23 families in which it was possible to compute this index for two siblings. The intraclass correlation coefficient is .62

TABLE 16

Indices	Males	Females
-5.9 thru -5.0	4	1
-4.9 " -4.0	6	4
-3.9 " -3.0	6	8
-2.9 " -2.0	8	9
-1.9 " -1.0	12	12
- .9 " 0	8	11
.1 " 1.0	6	3
1.1 " 2.0	2	7
2.1 " 3.0	5	7
3.1 " 4.0	4	1
4.1 " 5.0	2	3
5.1 " 6.0	6	4
6.1 " 7.0	1	3
7.1 " 8.0	1	1
8.1 " 9.0		
9.1 " 10.0		
10.1 " 11.0	1	
Total	72	74

for the 23 pairs. This is a high correlation and suggests further studies centering in the family.

The statistical analysis of these data show a consistent pattern and order of eruption of the deciduous teeth. Minor differences, some statistically significant, occur between the sexes and the jaws. Some of these are in agreement with past studies but none may be of real dental significance. Perhaps of greater interest is the small percentage of children who do not conform to the general pattern. There is evidence of the existence of early and late erupting groups. The rapidity of dentition is quite variable. Siblings show similarity in both tooth eruption and caries. It is expected that future papers by authors associated with the Growth Study at the Harvard School of Public Health will deal with the relation between eruption and decay and other variables such as the diet of the children and of their mothers during pregnancy. It is hoped that the indices here given will facilitate the study of these associations.

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STUDIES OF PUPILS OF THE PENNSYLVANIA SCHOOL FOR THE DEAF

III. AN ANALYSIS OF SPEECH CHARACTERISTICS IN DEAFENED CHILDREN WITH OBSERVATIONS ON TRAINING METHODS[1]

WALTER HUGHSON, ANTONIO CIOCCO, E. G. WITTING, AND P. S. LAWRENCE

INTRODUCTION

From the standpoint of public health, the problems of "deaf-mutism" cannot be attacked in as direct fashion as can those of other types of physical impairment. Little can now be done about prevention because little is known about the etiology of the disease. Furthermore, it is probable that inheritance is the most important factor. In a non-eugenic society, therefore, appropriate preventive measures cannot be taken. Realization that heredity is a primary causative element and the accepted view that damage to the auditory apparatus is nearly complete and irreversible have not only discouraged more determined inquiry about prevention but have also discouraged attempts at medical or surgical therapy. While such pessimism has some foundation, it is probably not definitely warranted. At least, the present investigation by the Otological Research Laboratory of the Abington Memorial Hospital, made in cooperation with the Division of Public Health Methods of the National Institute of Health and the Pennsylvania School for the Deaf, was undertaken more hopefully.

The only aid that can now be offered deaf-mute children is in habilitation, that is, training them to utilize residual hearing and to speak. To that end are dedicated the efforts of the teachers and schools for the deaf. The results of such efforts cannot, however, be fully appreciated unless quantitative evaluation is made of the methods employed. Only after evaluation will it be possible to arrive at a criterion of the benefits that deaf-mutes can derive from training and at a sound basis for the development of more efficient programs of teaching. With that purpose in mind, this study concerning the speech of children who have received auricular training is presented. Auricular training, as the term is now employed, consists of teaching children by means of amplified sound to utilize residual hearing.

The early reports of auricular or acoustic training of deafened children with subsequent improvement in the hearing level are now largely of academic interest. Measurement of the original impairment level could not be accurate with testing methods then in use, consequently reported improvement was a matter of opinion, not of record. French, English, and German otologists reported between 1761 and 1860 the effect of auricular training. Probably the first mention of such teaching of the

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In a cooperative enterprise such as this, although the division of labor is never sharply defined, it is to be expected that each of the authors has contributed mainly to only one specific aspect of the study. In fairness to the authors and readers it may be stated that W.H. and A.C., who envisioned the study, have prepared this report in its final form, E.G.W. has been in charge of the technical organization of the survey, and P.S.L. of the statistical analysis.

deaf in the United States appeared in the "Annual Report of the Oral Branch of the Pennsylvania Institute for the Deaf and Dumb," December 31, 1883. An excerpt from that report (1) follows:

> "The pupils in our school are classified in the following manner: Congenital mutes and those who have lost hearing before acquiring speech are placed by themselves, semi-mutes are classed together, and semi-deaf pupils form another class.
>
> "We believe from our own experience, and from accounts that have reached us from other sources, that the hearing of the semi-deaf and of those who have a very slight appreciation of sound is capable of improvement; therefore, we work to develop their hearing while we do not ignore lip-reading, lest the hearing of some of them may never become sufficient without its aid.
>
> "After a three months' trial of the audiphone with all pupils who appeared to have the slightest appreciation of sound, we have discontinued its use, as it has not seemed to aid the hearing of any of our pupils. I wish distinctly to state that I do not condemn the instrument as useless in all cases, I only say it has not seemed to aid those on whom we have carefully experimented."

In the early 1890's Gallaudet (2), Currier (3), and Gillespie (4) published reports of similar efforts but, contrary to the Pennsylvania School's experience, their results had been highly gratifying. It is interesting to note that effective results were obtained only among the "semi-deaf". That fact must be borne in mind in any critical appraisal of the auricular method as practiced before the audiometer was routinely used to measure hearing loss.

Goldstein (5 and 6) in his two monographs describes in detail Urbantschitsch's contribution to the general program of auricular training in the early 1890's and his own efforts from 1895 to 1920. For that period, since there were no precise methods to measure hearing loss, no data are available relative to actual changes in hearing level of "semi-deaf" or partially deaf children. There is no reason to doubt, however, that those pupils did acquire certain elements of speech as a result of such training.

In 1936 Guilder and Hopkins (7) drew attention to the importance of grouping children with residual hearing into classes of individuals with similar hearing losses. Newhart (8) in 1937 re-emphasized the importance of that practice in relation to the use of group hearing aids among children with a hearing loss of 40 decibels or more. He stated further, "The use of a hearing device by the child with a handicapping loss of hearing will in the near future probably be as common as is the use of corrective glasses by the child with a visual defect causing an equal handicap." Unfortunately the five intervening years have not been the measure of "the near future". It may be stated here that that result will never be achieved unless public school officers cooperate more fully by placing children in schools equipped to give them highly specialized training. It is felt that the specific information presented here may serve to point out some phases of the subject more thoroughly than any amount of argument could do.

Purely as a matter of record and with no claim to priority, we note that in 1931 there was installed at the Pennsylvania School for the Deaf an electrical group hearing aid to instruct 10 pupils. Since that time the method has been expanded to 21 classes in the year 1940-1941, or about 44 per cent of the School's resident student population of 540. A report (9) of the auricular program in the Pennsylvania School for the Deaf (Volta Review 1937) is inserted here as a background for the data which are to follow:

"In November 1931 the first group hearing aid was installed in the Intermediate Department with ten pupils grouped for instruction. At present there are eleven rooms equipped and a hundred and eighteen pupils receiving their entire instruction by means of the sight-hearing method. Five of these classes are in the Primary, four in the Intermediate and two in the Advanced Departments.

"With our large enrollment and the increasing number of classes it is possible to have a definite progression within each department and from one department to another. For the past four years we have been able to form one or two classes from the entering group, and to place individual pupils in classes already started.

"These pupils range in age from six to nine years, and although there is a wide variation in their background and previous training, the classes are fairly well graded.

Entering Group:

"Very few of our entering pupils can be classed as belonging to the hard of hearing group. In order to determine which ones have sufficient hearing to be able to use a hearing aid to advantage, tests are given to all of the entering children.

"As sense training, 'listening' - trying to make the child conscious of sound - is introduced as follows:

I. Gross sounds - drum, gongs, horns, bells, cymbals, whistle, rattle, etc.
II. Tuning forks - 5 in number
288 - 456 - 912 - 1824 - 3648 cycles.
III. Voice - the vowel - work - sentence tests.
(a) Natural voice close to ear
(b) Natural voice using bilateral tube
IV. Voice - pitch
V. 3-A Audiometer
VI. Discrete Frequency Audiometer

"Usually before the tests are completed, we have found a sufficient number of partially deaf children to form an auricular class.

Training with Group Hearing Aids:

"We begin with two short periods a day - then three. Gradually the periods are lengthened. Music (records) is used for stimulation and training.

I. With eyes closed pupils tell when the music is being played, when not.

II. Recognize difference in pitch - violin and cello, of the flute and bassoon.

III. Recognition of different instruments from records played - piano, organ, etc. About eighteen or twenty instruments are recognized.

IV. Pointing out simple rhythm in 2/4, and 4/4 and 3/4 time.

"The child recognizes the rhythms for marching, skipping, running, and dancing, etc.

"Later when language has been acquired much pleasure is derived from the vocal records - Mother Goose Rhymes and folk songs. Pupils also learn to follow the notes of simple rhythms.

"This training and stimulation prepares the way for the work with the voice that is to follow.

Speech Development:

"Beginning work on articulation is given through hearing as well as through sight and touch. Great care must be exercised in getting correct positions for elements, particularly consonants. This is sometimes much more difficult with the partially deaf child because he very often has faulty positions or substitutions. Vowels are more easily taught and contrasted. Normal pitch and quality can be obtained and speech is generally more intelligible due to the greater ease with which accent and phrasing can be acquired.

Vocabulary:

"With the use of a group hearing aid the pupils are in a more normal situation to acquire speech and language. Words are learned in their natural relationship and not learned merely as words in an articulation drill. Natural expressions and idiomatic phrases are picked up readily after the foundation for speech is laid.

Lip-reading:

"Lip-reading is given with and without the earphones i.e., periods for seeing alone, periods for hearing alone and others for seeing and hearing.

"With the more normal situation in the schoolroom the children seem to acquire lip-reading more or less unconsciously, and with very few exceptions they apparently read the lips as well without the ear phones as with them. The lip-reading background grows with auditory background and the acquisition of language.

Language Development:

"Language development is decidedly more rapid and the language itself is less stilted and more flexible. There is evidence of better sentence construction and fewer mistakes than are usually attributed to deaf children. Language principles are more easily and naturally taught and these pupils seem to remember when and how to apply them. They use them more spontaneously in talking to each other in and out of the classroom. This is particularly true of their first independent language as shown in their daily news, letters, et cetera.

Comparison of Two Groups of Children in Primary Department:

"(Note - although it is rather difficult to compare two groups, these two groups were selected as being comparable as to mentality, age, and length of time in school).

I. Group with sufficient hearing to use hearing aid. Third year in school.
II. Profoundly deaf. Third year in school.

"Group I - Work was decidedly retarded the first year in comparison to Group II due to the additional training and stimulation of hearing. Less language taught but children used it more freely. By the middle of second year Group I had caught up to Group II and was forging ahead. At the present time Group I is far in advance of Group II in natural use of language.

"Visitors going from one class to the other seem to be impressed with the difference in speech and language; although Group II undoubtedly has more accurate speech, it is less intelligible to the average person than that of Group I.

"It is difficult to say just how much the use of the group instruments will accelerate the education of the pupils. This will not be possible until several of the classes, whose training began at the entrance into the school, have reached the Advanced Department. However, classes in the Intermediate and Advanced Departments are showing that their work compares very favorably with the work of the same grades in the Public School. It is not unreasonable to believe that the retardation that exists at entrance can be almost wholly overcome before graduation. Many of the pupils who were in the partially deaf group when their training began can now be classified as hard of hearing, and as such will take their places in the hearing world."

Study of the reports of the "Committee on the Use of Residual Hearing of the American Association to Promote the Teaching of Speech to the Deaf" sheds interesting light upon modern developments in the auricular method of the training of hearing and speech. In the Volta Review 1937 (10) and later in June 1940 (11) extensive questionnaire surveys are reported; the increase in the use of group hearing aids was approximately 60 per cent in the 106 schools replying to the inquiry. In view of the numerical increase in auricular equipment among schools for the deaf, one item of the report is revealing since it shows why the schools were willing to make the additional expenditure to procure hearing aid equipment. To the question, regarding the goal schools hope to achieve by acoustic training, the majority replied: "To improve speech." There can be little question that among pupils having very little residual hearing speech can be thus taught with greater facility, but with how much greater facility? The use of the sense of hearing is taught but can it be said that hearing is actually improved? There is not adequate objective evidence available at the present time to substantiate any such claim. Undoubtedly some will take issue sharply with that statement.

The present study provides, for the first time, a detailed analysis of articulation ability in children taught by both auricular and oral

methods. Since auricular training is self-limited, it cannot be used at all with children who have no usable residual hearing. Accordingly, children can be readily divided into groups on a purely audiometric basis. The majority group of deaf children must, however, still be the chief concern of physicians and teachers alike. Hence, if success in the auricular method is fully realized, the ultimate saving of time and money resulting from such training of the fortunate 35 to 45 per cent with residual hearing will make available an important sum of money for instruction of the less fortunate majority.

Before presenting a method of speech analysis one important point about the technique of auricular training must be emphasized. It is not a distinctive pedagogical method, but is only an application of standard teaching practice by means of scientifically designed electrical acoustic equipment. There is now no need for flutes, horns or other mechanical sources of sound since it is possible to apply any acoustic stimuli to the deafened ear at accurately measured intensity levels with complete regard to reproduction of any quality desired.

THE MATERIAL AND THE TECHNIQUE OF RECORDING AND GRADING SPEECH RECORDS

The speech of each of the children enrolled in the Pennsylvania School for the Deaf (and present at the time of a survey in the spring of 1940) was electrically transcribed. However, only records of those children who had in the previous year (1939) received an audiometric examination (12, 13) are discussed in this paper. The records concern 367 children or over two-thirds of the enrollment of the school.

The electrical transcriptions were made with a Presto Jr. Recorder (Model JS) using cellulose acetate twelve-inch discs. It was possible to record 8 recitations per disc (4 on each side). The speaker was seated comfortably in front of the microphone and every attempt was made to minimize nervousness which was a comparatively minor factor because many of the children had experienced the procedure at least once before. The microphone, of the condenser type, was placed about 6 inches in front of the speaker's mouth vertically but at an angle of 45 degrees to it in the horizontal plane. The placement of the microphone tended to reduce, if not eliminate, overemphasis of sounds which are normally explosive in nature. After detailed instruction each child read the word list (shown below) once as a trial run. The operator was thus enabled to adjust the amplifier volume to each child. The procedure also served to familiarize the pupil with the words to be recited.

The words in the list read by the child consist of all vowels and consonants in our English language used in as many of their combinations as feasible, consonants being used in both initial and final positions wherever possible. We are indebted to Miss Margaret Bodycomb of the Pennsylvania School for the Deaf for the compilation of those sounds into a word list familiar to all pupils whose speech was recorded. The first 10 words are the cardinal numbers, repetition of which provided the proper rate of pronunciation of all the words. The following words were used:

One	father	this
two	pie	foot
three	coat	rung
four	mouth	spoon
five	zoo	dog
six	toy	love
seven	top	you
eight	date	
nine	bird	
ten	cat	

The following sounds are embodied in the word list:

ä - broad a (father)	ō - long o (coat)
ā - long a (date)	ŏ - short o (rung)
ă - short a (cat)	ô - broad o (four)
ē - long e (three)	ū - long u (foot)
ĕ - short e (seven)	oi - diphtong (toy)
ī - long i (nine)	
ĭ - short i (this)	

The grading of the electrically transcribed records was done alone by one of the authors (E.G.W.) who, except for knowing name and age, was unaware of the class, type of training, hearing ability or other attribute of the child whose speech ability was being judged. Grading of speech characteristics consists of subjective evaluation of how the word, vowel, or consonant as spoken by the deaf child compares with the enunciation of a normal hearing child of similar age and educational level. In order to acquire an adequate foundation for such a comparison, electrically transcribed records were made of the voices of a sample of school children who had not received speech training other than that routinely given in public schools. The records of these children were studied with reference to the same speech characteristics as those investigated in the case of the deaf children and a criterion of "good" or "normal" was thus set up.

The form employed in grading the speech records and the speech characteristics analyzed are illustrated in Figure 1. It is seen from Figure 1 that for the words listed the speech characteristics studied are: articulation; explosiveness and audibility of the first consonant; holding, explosiveness and quality of the vowel; explosiveness and audibility of the final consonant; syllable continuity; and expression.

The term articulation was employed to mean whether the word was unmistakably, doubtfully, or very badly spoken.

Good: Articulation as good as that of a normal hearing individual, leaving no question as to the word pronounced.

Fair: Recognizable with some difficulty, or recognizable even though some of the sounds were modified.

Poor: Not recognizable as the word intended, at least upon the first playing of the record.

Explosiveness refers to classification of the degree of emphasis placed by the speaker on the enunciation of a vowel or consonant. The term is applied to the type of enunciation which might result if the sound required does not emerge with the initial application of energy.

FORM A

NAME_____ CASE NO._____ DEPT._____ AGE_____
YEARS IN SCHOOL_____
AURICULAR_____

WORD	ARTIC.			FIRST CONS. EXP.			FIRST CONS. AUD.			VOWEL HOLD.			VOWEL EXP.			VOWEL QUAL.			FINAL CONS. EXP.			FINAL CONS. AUD.			SYL. CONT.			REMARKS
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
ONE				--	--	--	--	--	--										--	--	--				--	--	--	
TWO																			--	--	--	--	--	--	--	--	--	
THREE																			--	--	--	--	--	--	--	--	--	
FOUR																									--	--	--	
FIVE																									--	--	--	
SIX																									--	--	--	
SEVEN																												
EIGHT				--	--	--	--	--	--																--	--	--	
NINE																									--	--	--	
TEN																									--	--	--	
FATHER																												
PIE																			--	--	--	--	--	--	--	--	--	
COAT																									--	--	--	
MOUTH																									--	--	--	
ZOO																			--	--	--	--	--	--	--	--	--	
TOY																			--	--	--	--	--	--	--	--	--	
TOP																									--	--	--	
DATE																									--	--	--	
BIRD																									--	--	--	
CAT																									--	--	--	
THIS																									--	--	--	
FOOT																									--	--	--	
RUNG																									--	--	--	
SPOON																									--	--	--	
DOG																									--	--	--	
LOVE																									--	--	--	
YOU				--	--	--	--	--	--										--	--	--	--	--	--	--	--	--	

EXPRESSION:

Figure 1

Sudden realization that no sound has been produced gives rise to a burst of energy resulting in a sound that is abnormally loud. That phenomenon occurs with the "p" and "b" sounds if the lips are held closed while the lungs are attempting to force air between them. The pressure eventually increases sufficiently to part the lips and produce a burst of sound. A similar effect is observed if vowel sounds are produced by sudden lung pressure instead of a steady, smooth flow. Over-emphasis is a well known characteristic of the speech of persons with certain types of deafness.

Audibility refers to the ability of the speaker to pronounce vowels or consonants so that they are fully perceived by a listener. Obviously, there is a certain correlation between explosiveness and audibility. Consonants pronounced in an over-explosive manner will also sound louder than normal. However, even when explosiveness is normal the vowel or consonant may depart from normal sound intensity.

Holding, in our classification, is concerned with the excellence of the spoken vowel in terms of voicing. Because of the method of teaching speech to deaf children, the habit of prolonging and emphasizing the sound of the vowel is often retained. The short duration of vowel sounds in many words makes it necessary to over-maintain a vowel sound while it is being taught. When the pupil is thoroughly familiar with the production of the sound, over-emphasis is no longer desirable.

However, it is probable that less attention is given to obtaining the correct duration of the sound than to its realization. Hence, in order to be certain of the production of the vowel the pupil holds the tone for too long a period.

The term quality refers to the pitch characteristic of a vowel. Because of the dependence of vowel sounds on the predominance of certain harmonics, it is possible to effect changes in the quality of the vowel in accordance with the ability of the pupil to imitate the correct mouth, throat and nasal resonance. Certain types of hearing loss also distort the original sound because the deafened ear does not perceive it with the harmonics in their correct relationship. The vowel e (three) is often heard and pronounced as u (two) or as a sound which borders on the oo (two) sound. Other deviations or changes in quality may also be produced.

The term syllable continuity is readily understandable. Just as young children learn words by syllables, and often seperate them when they should not, so do the deafened. On the other hand, many normal hearing individuals slur the transition from one syllable to another and deafened pupils sometimes carry the transition to the same extreme. There are only two double syllable words in the list but they are sufficient to indicate the trend.

Expression is used to mean whether the deaf child has: 1) Spoken all words in the list with the same expression as would be used by a normal hearing child, 2) Spoken some in a monotone, 3) Spoken all in a monotone.

In grading the several speech characteristics a triple classification (not the same for all characteristics) was employed and in marking the grade a check was placed in the appropriate column under the heading: 1, 2, or 3. The following is the system of grading:

Articulation: 1, Good; 2, fair; 3, poor.
Explosiveness: 1, Less than normal; 2, normal; 3, greater than normal.
Audibility: 1, Inaudible; 2, normal; 3, louder than normal.
Holding: 1, Staccato (shorter than normal); 2, normal; 3, longer than normal.
Quality: 1, Approximately normal; 2, slight modification; 3, extreme modification.
Syllable continuity: 1, Too fast (slurring); 2, normal; 3, too slow (marked separation).
Expression: 1, Normal; 2, monotone in some sounds; 3, monotone in most or all sounds.

It was hoped at first that all characteristics could be graded simultaneously. However, as was immediately apparent, that would not be feasible, even after considerable practice. As a result of some experimentation a routine procedure finally adopted consisted of playing each child's record 6 times. With the first playing, articulation and syllable continuity were graded; at the second, attention was focussed on the first consonant of words containing an initial consonant and, simultaneously, both explosiveness and audibility were graded. The third playing was used to judge holding of the vowel; the fourth, explosiveness; and the fifth, quality. Both the explosiveness and audibility of the final consonant were graded on the sixth playing.

It is worthy of mention that great care was necessary to preserve records so that each subsequent playing would be equal to the first in reproduction quality. The soft surfaces of cellulose acetate discs are much more liable to damage than are those of ordinary hard surface records. Since each recording occupied only one quarter of one side of a disc, there was very little wear on the needle; nevertheless, to avoid any possibility of wear, the needle was changed for each playing and the disc was lubricated with a fluid which leaves a thin wax film. Special shadowgraphed needles were used throughout, thus eliminating the possibility of irregular or extremely sharp needles distorting the record grooves. As a test, two recordings were played 50 times each under these conditions but in neither instance could a change in reproduction be noted as between first and last playings.

ANALYSIS OF DATA

Of 367 deaf children whose speech characteristics are discussed here, 249 had never received auricular training; 119 were, at the time of recording, enrolled in auricular classes. Among the non-auricular ("oral") group some speech characteristics could not, for a number of reasons, be graded; hence, in the tables the numbers of cases and of words spoken will vary somewhat.

Table 1 and Figure 2 show the frequency with which the speech was found to satisfy the defined gradation relative to the several elements considered. For all the speech characteristics, except expression, the percentages in this and following tabulations are calculated in terms of all words spoken by the entire group. With reference to expression, percentages are based on the number of children, since judgment of expression was based on the whole performance of each child.

From Table 1 it is seen that expression is the element in which deaf children deviate most markedly from normal. Only 6 per cent of the 367 children were regarded as having a normal speaking inflection or expression. The majority spoke some or all of the words in a monotone. In articulation and quality of vowel pronunciation the deaf children also deviate markedly from normal. Articulation was normal for only 18 per cent of all words spoken; vowel quality for only about 25 per cent. The children make a better showing in holding the vowel, since 58 per cent of the words were spoken normally in that respect although 41 per cent were held longer than normal. In the other elements examined: explosiveness of vowel, explosiveness and audibility of first and final consonants, and syllable continuity, the children differ remarkably little from normal. In particular, it is to be noted that with reference to pronunciation of the first consonant and explosiveness of the vowel, over 80 per cent of the words were spoken normally. The findings, while they conform in general to the expectations of those experienced in teaching the profoundly deaf, may be regarded as a first quantitative appraisal of the great strides made during the last fifty years in the habilitation of deaf children, and of the direction where further progress is needed.

It must not be forgotten, as one examines these data showing the high proportion of children who can enunciate normally certain speech elements, that less than two generations separate these children from

TABLE 1

QUANTITATIVE CHARACTERISTICS OF THE SPEECH OF THE PUPILS OF THE PENNSYLVANIA SCHOOL FOR THE DEAF IN RELATION TO TYPE OF SPEECH TRAINING RECEIVED

Speech Element	Grade	Method of Training: Auricular No.	Auricular Per cent*	Oral No.	Oral Per cent*	Both No.	Both Per cent*	P. for x^2 of auricular vs. oral
Expression	Normal	20	16.95	3	1.21	23	6.28	.000000
	Some Monotone	65	55.08	72	29.03	137	37.43	
	All Monotone	33	27.97	173	69.76	206	56.28	
	Total	118	100.00	248	100.00	366	99.99	
Articulation	Normal	1499	47.27	268	4.00	1767	17.89	.000000
	Fair	987	31.13	2473	36.89	3460	35.04	
	Poor	685	21.60	3963	59.11	4648	47.07	
	Total	3171	100.00	6704	100.00	9875	100.00	
Quality of vowel	Normal	1711	54.46	637	9.95	2348	24.60	.000000
	Fair	1198	38.13	3530	55.12	4728	49.53	
	Poor	235	7.42	2237	34.93	2470	25.87	
	Total	3142	100.01	6404	100.00	9546	100.00	
Holding of vowel	Staccato	42	1.34	45	0.70	87	0.91	.000000
	Normal	2130	67.90	3436	53.74	5566	58.40	
	Long	965	30.76	2913	45.56	3878	40.69	
	Total	3137	100.00	6394	100.00	9531	100.00	
Explosiveness of vowel	Less than normal	8	0.25	46	0.72	54	0.57	.000000
	Normal	2571	81.88	5331	83.30	7902	82.83	
	Greater than normal	561	17.87	1023	15.98	1584	16.60	
	Total	3140	100.00	6400	100.00	9540	100.00	
Explosiveness of 1st Cons.	Less than normal	135	4.82	672	11.79	807	9.49	.000000
	Normal	2400	85.68	4694	82.35	7094	83.45	
	Greater than normal	266	9.50	334	5.86	600	7.06	
	Total	2801	100.00	5700	100.00	8501	100.00	
Audibility of 1st Cons.	Inaudible	134	4.78	674	11.85	808	9.52	.000000
	Normal	2400	85.65	4646	81.68	7046	82.99	
	Loud	268	9.56	368	6.47	636	7.49	
	Total	2802	99.99	5688	100.00	8490	100.00	
Explosiveness of Final Cons.	Less than normal	251	10.74	546	11.49	797	11.24	.162676
	Normal	1796	76.88	3722	78.29	5518	77.83	
	Greater than normal	289	12.37	486	10.22	775	10.93	
	Total	2336	99.99	4754	100.00	7090	100.00	
Audibility of Final Cons.	Inaudible	255	10.39	548	10.94	803	10.76	.917216
	Normal	1768	72.05	3539	70.67	5307	71.12	
	Loud	431	17.56	921	18.39	1352	18.12	
	Total	2454	100.00	5008	100.00	7462	100.00	
Syllable Continuity	Slurring	15	6.47	50	10.92	65	9.42	.188438
	Normal	180	77.59	312	68.12	492	71.30	
	Separation	37	15.95	96	20.96	133	19.28	
	Total	232	100.01	458	100.00	690	100.00	

*Per cent of children in the case of expression, per cent of words spoken in the case of other elements.

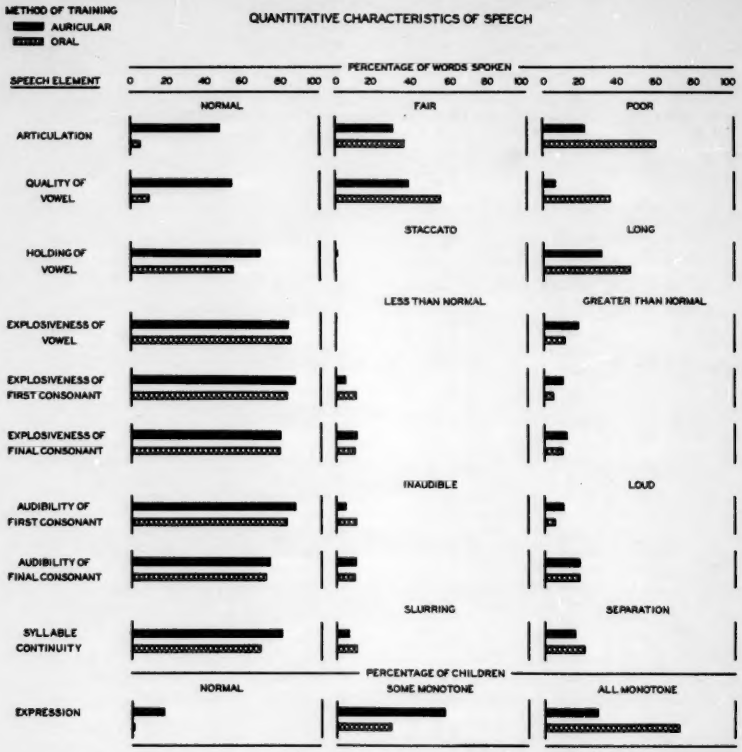

Figure 2

deaf-mutes unable to emit other than meaningless sounds. As a result of modern methods of caring for the deaf, mutism caused by auditory deficiency has been overcome to a very appreciable degree relative to the enunciation of consonants. There still remains, however, the problem of overcoming the deficiency of the voicing of vowels and of expression and articulation. Apparently more emphasis is needed on methods of training to overcome those speech shortcomings.

When the speech characteristics of the auricularly trained are compared with those of the orally trained striking differences are observed. The superiority of the auricularly trained concerns precisely those elements that make up most of the deviation of the children's speech from normal: Expression, articulation and vowel quality. Almost 17 per cent of the auricular group (but only 1 per cent of the oral) spoke with good expression. Word articulation and the voicing of vowels were

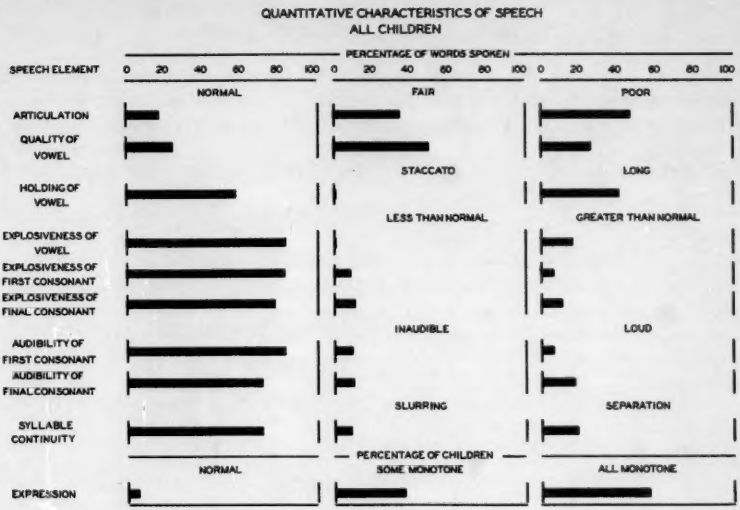

Figure 3

regarded as normal in approximately 50 per cent of the words spoken by the auricularly trained group but in fewer than 10 per cent of those spoken by the orally trained. The differences are not only striking but also statistically significant, as the values of the probability based on the chi-square test illustrate. Although not so striking, the superiority of the auricular group is also statistically significant relative to the holding of the vowel. For each of the remaining elements the percentage of normal enunciation is about the same in the two groups. The auricular group is somewhat superior relative to explosiveness and audibility of first consonant, audibility of final consonant, and syllable continuity while the oral group has a higher percentage of normal speech relative to explosiveness of vowel and of final consonant.

The differences between pairs of corresponding percentages are statistically significant only with regard to explosiveness and audibility of first consonant. For those elements differences between the two groups are also statistically significant relative to the frequency distributions of the gradations. This is due primarily to a tendency of the auricular group to over-emphasize enunciation of the consonant, while the oral group does the reverse, that is, tends to under-emphasize. That diversity in the speech characteristics of the two groups is apparent also, but to a lesser degree, in the case of explosiveness of vowel and of final consonant.

In summary, the present comparison of the speech characteristics of the auricular and oral groups reveals that for the elements considered,

the speech of the auricular is more nearly normal than is that of the oral group. The superiority of the auricular group is particularly marked in respect to vowel quality, expression and articulation, the elements in which the speech of deaf children is most deficient. Moreover, it is also noted that the auricularly trained children, when compared to those orally trained, show a tendency to over-emphasize certain elements of speech, especially enunciation of the first consonant. Those are the differences between the groups of children who were the subjects of different types of training, but the significance of those differences cannot be discussed as yet.

The criterion by which children are selected to be given auricular training is based upon response to stimulation and training of hearing, plus the collective judgment of the teachers that a child will profit by such training. Although no rigid rules have been formulated to delineate precisely the criterion of selection, it obviously involves an evaluation of hearing ability which in itself would influence speech learning, aside from any method of training. It is well to point out this fact in order that it will be realized that, before any definitive conclusion can be drawn about differences between the speech characteristics of the two groups of children, the many factors involved in such differences must also be considered.

AUDITORY ACUITY AND SPEECH CHARACTERISTICS

That the amount of auditory perception still retained by the deafened child will influence his speech characteristics goes without saying, but on this point there are two questions pertinent to this study which should be considered carefully. The first concerns the comparability of the auricular and oral groups and whether the observed differences between them might not be due to a selection of the children on the basis of hearing ability. The second concerns the effects of sound stimulation, inherent in the auricular method, on children with very little residual hearing. The auditory acuity of the children has been measured by audiometer and was described in the first paper of this series. On the basis of the perception of the better hearing ear the children have been classified in three categories: 1) Those who perceive at any intensity all tones from 128 cycles to at least 2048 cycles per second, 2) those who perceive at any intensity only tones from 128 to 1024 cycles, and 3) those who perceive no tones at the highest intensity of the audiometer or perceive at best only 128, 256 and 512 cycles. That classification is founded on the observation, already pointed out, that, in the majority of these children, the auditory threshold lowers as one proceeds from low to high auditory frequencies, - which would mean that children who perceive the highest tones also have the lowest auditory threshold. Consequently, those who perceive at least 2048 cycles have the best auditory acuity in the 3 groups, those who perceive no tone higher than 512 cycles have the worst.

The speech characteristics of the auricular and oral groups of children whose auditory acuity has been so classified, are compared in Table 2. From Table 2 it becomes immediately obvious that hearing ability is an important element in the selection of the children en-

TABLE 2

FREQUENCY OF NORMAL ELEMENTS IN THE TRANSCRIBED SPEECH OF THE PUPILS OF THE PENNSYLVANIA SCHOOL FOR THE DEAF IN RELATION TO TYPE OF TRAINING RECEIVED AND AUDITORY ACUITY

Speech Element	Method of Training	Highest Tone Perceived: 2048 or higher No.	Per cent	Normal*	1024 No.	Per cent	Normal*	512 or lower No.	Per cent	Normal*	Total No.	Per cent	Normal*
Expression	Auricular	18	66.67	± 11.11	41	9.76	± 4.63	59	6.78	± 3.27	118	16.95	± 3.45
	Oral	8	0.00	± ---	45	2.22	± 2.20	195	1.03	± .72	248	1.21	± .89
Articulation	Auricular	456	92.11	± 1.26	1157	37.42	± 1.42	1558	41.46	± 1.25	3171	47.27	± .89
	Oral	216	5.09	± 1.50	1215	5.60	± .66	5273	3.58	± .26	6704	4.00	± .24
Quality of vowel	Auricular	483	95.65	± .93	1129	48.54	± 1.49	1530	45.82	± 1.27	3142	54.46	± .89
	Oral	216	11.57	± 2.18	1107	12.38	± .99	5081	9.35	± .41	6404	9.95	± .37
Holding of vowel	Auricular	483	98.76	± .50	1127	64.95	± 1.42	1527	60.31	± 1.25	3137	67.90	± .83
	Oral	216	57.87	± 3.36	1107	50.32	± 1.50	5071	54.31	± .70	6394	53.74	± .62
Explosiveness of vowel	Auricular	483	94.20	± 1.06	1128	79.79	± 1.20	1529	79.53	± 1.03	3140	81.88	± .69
	Oral	211	92.42	± 1.82	1104	83.06	± 1.13	5085	82.97	± .53	6400	83.30	± .47
Explosiveness of 1st Cons.	Auricular	431	94.66	± 1.08	1005	85.57	± 1.11	1365	82.93	± 1.02	2801	85.68	± .66
	Oral	192	88.54	± 2.30	984	77.24	± 1.34	4524	83.20	± .56	5700	82.35	± .50
Audibility of 1st Cons.	Auricular	431	94.66	± 1.08	1005	85.27	± 1.12	1366	83.09	± 1.01	2802	85.65	± .66
	Oral	192	87.50	± 2.39	983	76.40	± 1.35	4513	82.58	± .56	5688	81.68	± .51
Explosiveness of final Cons.	Auricular	359	91.64	± 1.46	839	74.97	± 1.50	1138	73.64	± 1.31	2336	76.88	± .87
	Oral	160	84.37	± 2.87	820	81.34	± 1.36	3774	77.37	± .67	4754	78.29	± .60
Audibility of Final Cons.	Auricular	377	91.25	± 1.46	881	70.83	± 1.53	1196	66.89	± 1.36	2454	72.05	± .91
	Oral	168	73.81	± 3.39	865	69.60	± 1.56	3975	70.77	± .72	5008	70.67	± .64
Syllable Continuity	Auricular	36	88.89	± 5.24	84	72.62	± 4.87	112	77.68	± 3.93	232	77.59	± 2.74
	Oral	16	56.25	± 12.40	82	59.76	± 5.42	360	70.56	± 2.40	458	68.12	± 2.18

*Per cent of children in the case of expression, per cent of words spoken in the case of other elements.

rolled in the auricular classes. Of all children who perceived 2048 cycles or higher, about two-thirds are in the auricular group, but of the children who at best perceived only 512 cycles, only about one-quarter are in this group. Notwithstanding the selection, however, it is evident that with equal auditory acuity there are still differences between the two groups. With regard to expression and word articulation, quality and holding of vowel, audibility of first consonant, and syllable continuity the superiority of the auricular group is consistent in each auditory acuity class but is most striking for the first 3 elements.

With reference to explosiveness of vowel and of first and final consonants, and audibility of final consonant the differences are not consistent in direction when the three auditory acuity classes are examined. It would seem safe to infer that independently of the auditory acuity of the children the speech characteristics of those who have received auricular training are superior to those who have not, particularly relative to expression and articulation of word and holding of vowel, the elements in which the deaf children deviate most from normal. Moreover, when the results obtained from children who perceive at least 2048 cycles are specifically considered, the utilization of residual hearing by the auricular method is shown very clearly. On the whole and except for expression, the auricularly trained children in this auditory acuity class deviate little in their performance from normal hearing children. In contrast, the speech of the orally trained children with the same auditory acuity deviates from normal to almost the same degree as does that of the orally trained who can perceive at best only 512 cycles. The auricular group in this lowest auditory acuity class are also of interest. It appears that even with minimal residual hearing the group is significantly superior to the orally trained with respect to the most important speech characteristics. It is of interest to point out that in neither training group does one note a great difference between the speech of those who perceive only as high as 1024 cycles and those who perceive at best only as high as 512 cycles. The marked difference between the speech of children who can perceive at least 2048 cycles and that of those who cannot - as observed in the auricular group in expression, word articulation and quality of vowel - brings out the importance of high tones in both speech and perception of it.

Summing up these findings, it appears that the speech of the auricular group of children approaches closer to that of normal hearing children than does that of the oral group under all conditions of residual hearing. The speech of the auricularly trained children is practically normal for the elements studied when the residual auditory acuity is such that at least 2048 cycles is perceived. The amount of residual auditory acuity apparently has little or no bearing on the speech response of the orally trained children.

AGE AT ONSET OF DEAFNESS AND SPEECH CHARACTERISTICS

Another factor that will influence speech characteristics of children and particularly the comparison of auricular with oral training is

the time at which deafness occurred. It is obvious that the later a child loses some or all of his hearing, the more speech he will have acquired and consequently the less difficulty he will have in learning to speak normally. That fact is well illustrated by the data presented in Table 3 in which, from the statements made by the parents (12), the age of onset of deafness has been classified: 0-2 years (includes those born deaf), 2½ to 4 years, 4½ years and over.

The principal findings which emerge from Table 3 may be outlined as follows:

1. For all the 10 speech elements studied in the case of the auricular group, and for 7 of the 10 elements studied in the case of the oral group, there is a definite and consistent tendency for the proportion of normally spoken words to increase as the age of onset of deafness advances.

2. The tendency is most marked in the case of elements that constitute the most distinctive difference between the speech of normal hearing children and that of deaf children.

3. The differences that have thus far been shown to distinguish the speech of the auricularly from that of the orally trained children are present in each age-of-onset class.

Hence, with respect to the comparison of the two groups the differences exist independent of age of onset of deafness. Moreover, with respect to expression and word articulation and quality of vowel the superiority of the auricular group is proportionally greater in the case of the children born deaf (or becoming deaf before two years of age) than in cases when deafness occurred after some speech had been learned. From this and the preceding section it is clear that while the age of onset of deafness (that is, the speaking experience already acquired) and the retained residual auditory acuity affect the ability of the child to learn speech, the superiority of the auricular group with respect to the speech elements: Expression and articulation of words, quality of vowel, and, to a lesser degree, syllable continuity, is manifest in all instances. For the first three elements it will be observed from Tables 2 and 3 that even under the most adverse conditions the percentage with normal speech among the auricularly trained children is higher than the corresponding percentage among the orally trained in the case of optimum conditions. For example, children in the auricular group whose auditory acuity does not extend beyond 512 cycles even if they became deaf at less than two years of age, are superior in expression, articulation and quality of vowel to children in the oral group who can perceive at least 2048 cycles if they acquired their hearing impairment after 4½ years of age. It seems safe to conclude, therefore, that the differences between the auricular and oral groups as shown in Table 1 are not due entirely to selection of children relative to present auditory acuity or past speech experience but in all probability result from speech training.

AGE AT EXAMINATION AND SPEECH CHARACTERISTICS

It is next desired to know to what extent chronological maturation as well as duration of training affect the speech characteristics of the

TABLE 3

FREQUENCY OF NORMAL ELEMENTS IN THE TRANSCRIBED SPEECH OF THE PUPILS OF THE PENNSYLVANIA SCHOOL FOR THE DEAF IN RELATION TO TYPE OF TRAINING RECEIVED AND AGE AT ONSET OF DEAFNESS

Speech Element	Method of Training	Stated Age at Which Hearing Was Lost (to the Nearest Half Year)											
		Birth - 2			2½ - 4			4½ - over			All ages		
		No.	Per cent	Normal*	No.	Percent	Normal*	No.	Per cent	Normal*	No.	Per cent	Normal*
Expression	Auricular	85	10.59	± 3.34	22	27.27	±9.49	11	45.45	±15.01	118	16.95	± 3.45
	Oral	207	0.48	± .48	20	5.00	±4.87	21	4.75	± 4.65	248	1.21	+ .69
Articulation	Auricular	2284	38.57	± 1.02	590	62.03	±2.00	297	84.85	± 2.08	3171	47.27	± .89
	Oral	5598	1.23	± .15	540	11.48	±1.37	566	24.20	± 1.80	6704	4.00	± .24
Quality of vowel	Auricular	2257	44.26	± 1.05	590	74.75	±1.79	295	91.86	± 1.59	3142	54.46	± .89
	Oral	5297	5.23	± .30	540	23.33	±1.82	567	41.27	± 2.07	6404	9.95	± .37
Holding of vowel	Auricular	2250	62.71	± 1.02	590	77.12	±1.73	297	88.89	± 1.82	3137	67.90	± .83
	Oral	5287	52.41	± .69	540	51.85	±2.15	567	67.90	± 1.96	6394	53.74	± .62
Explosiveness of vowel	Auricular	2253	80.42	± .84	590	81.02	±1.61	297	94.61	± 1.31	3140	81.88	± .69
	Oral	5294	82.91	± .52	540	86.11	±1.49	566	84.28	± 1.53	6400	83.30	± .47
Explosiveness of 1st Cons.	Auricular	2010	83.33	± .83	527	88.99	±1.36	264	96.97	± 1.06	2801	85.68	± .66
	Oral	4715	80.85	± .57	480	84.17	±1.67	504	94.64	± 1.00	5700	82.35	± .50
Audibility of 1st Cons.	Auricular	2011	83.39	± .83	527	88.80	±1.37	264	96.59	± 1.11	2802	85.65	± .66
	Oral	4704	79.95	± .58	480	84.58	±1.65	504	95.04	± .97	5688	81.68	± .51
Explosiveness of final Cons.	Auricular	1677	74.60	± 1.06	439	79.27	±1.93	220	89.55	± 2.06	2336	76.88	± .87
	Oral	3934	78.01	± .66	400	77.25	±2.10	420	81.90	± 1.88	4754	78.29	± .60
Audibility of final Cons.	Auricular	1764	69.10	± 1.10	460	74.57	±2.03	230	89.57	± 2.02	2454	72.05	± .91
	Oral	4148	69.82	± .71	420	73.57	±2.15	440	75.91	± 2.04	5008	70.67	± .64
Syllable Continuity	Auricular	166	75.90	± 3.32	44	77.27	±6.32	22	90.91	± 6.13	232	77.59	± 2.74
	Oral	378	64.55	± 2.46	40	82.50	±5.58	40	87.50	± 5.13	458	68.12	± 2.18

*Per cent of children in the case of expression, per cent of words spoken in the case of other elements.

TABLE 4

FREQUENCY OF NORMAL ELEMENTS IN THE TRANSCRIBED SPEECH OF THE PUPILS OF THE PENNSYLVANIA SCHOOL FOR THE DEAF IN RELATION TO TYPE OF TRAINING RECEIVED AND AGE AT TIME OF EXAMINATION

Speech Element	Method of Training	Age: Under 15			Age: 15 and over			Age: All Ages		
		No.	Per cent	Normal*	No.	Per cent	Normal*	No.	Per cent	Normal*
Expression	Auricular	65	7.69	± 3.20	53	28.30	± 6.19	118	16.95	± 3.45
	Oral	109	2.75	± 1.57	139	0.00	---	248	1.21	± .69
Articulation	Auricular	1745	32.66	± 1.12	1426	65.15	± 1.26	3171	47.27	± .89
	Oral	2939	4.05	± .36	3765	3.96	± .32	6704	4.00	± .24
Quality of vowel	Auricular	1715	44.26	± 1.20	1427	66.71	± 1.25	3142	54.46	± .89
	Oral	2842	12.81	± .63	3562	7.66	± .45	6404	9.95	± .37
Holding of vowel	Auricular	1712	59.23	± 1.19	1425	78.32	± 1.09	3137	67.90	± .83
	Oral	2839	39.98	± .92	3555	64.73	± .80	6394	53.74	± .62
Explosiveness of vowel	Auricular	1715	73.06	± 1.07	1425	92.49	± .70	3140	81.88	± .69
	Oral	2847	79.91	± .75	3553	86.01	± .58	6400	83.30	± .47
Explosiveness of 1st Cons.	Auricular	1530	81.57	± .99	1271	90.64	± .82	2801	85.68	± .66
	Oral	2537	78.56	± .81	3163	85.39	± .63	5700	82.35	± .50
Audibility of 1st Cons.	Auricular	1531	81.97	± .98	1271	90.09	± .84	2802	85.65	± .66
	Oral	2535	77.51	± .83	3153	85.03	± .64	5688	81.68	± .51
Explosiveness of Final Cons.	Auricular	1276	73.51	± 1.24	1060	80.94	± 1.21	2336	76.88	± .87
	Oral	2115	74.09	± .95	2639	81.66	± .75	4754	78.29	± .60
Audibility of Final Cons.	Auricular	1339	66.84	± 1.26	1115	78.30	± 1.23	2454	72.05	± .91
	Oral	2241	62.43	± 1.02	2767	77.34	± .80	5008	70.67	± .64
Syllable Continuity	Auricular	128	67.19	± 4.15	104	90.38	± 2.89	232	77.59	± 2.74
	Oral	206	54.37	± 3.47	252	79.37	± 2.55	458	68.12	± 2.18

*Per cent of children in the case of expression, per cent of words spoken in the case of other elements.

two groups of children and the observed differences between them. The children examined varied in age from 8 to 21 years, with a mean age of 15.3 years. The mean age of the auricular group was 14.5 years, or about a year less than the mean age of the oral group, 15.6 years. The oral training group being older (since presumably speech ability is better in older children), indicates that the differences between the two groups of children cannot be attributed to greater maturity of the auricularly trained.

In order to study the effects of age and to render comparable the two groups (but at the same time not reduce the numbers too much) each has been subdivided into two age classes: Under 15, and 15 and over. The findings about speech characteristics of the groups, classified according to age, are presented in Table 4.

Table 4 shows that the speech of the older children deviates, on the whole, less from normal than that of the younger ones. However, in the cases of expression and articulation of words and quality of vowel, the older orally trained children are not superior to the younger ones and actually may be said to exhibit some inferiority. For example, among the orally trained children younger than 15, 2.8 per cent spoke with normal expression but in none of the children above 15 years of age was this observed.

From Table 4 it is also apparent that among the auricular group, the ones above 15 years of age demonstrate a net superiority over the younger ones. This superiority is especially striking with respect to those speech elements that constitute the characteristics which mainly distinguish the speech of the deaf children from those with hearing, and the speech of the auricularly from the orally trained children.

The findings seem to indicate that there is progressive improvement in the speech characteristics of the children with, however, the limitation that the auricularly trained progress in all the speech elements considered, but the orally trained do not progress in the important elements such as expression and articulation of word and quality of vowel. Since advancing age involves also longer training the influence of that factor must be studied before discussing further these observations.

DURATION OF TRAINING AND SPEECH CHARACTERISTICS

Table 5 and Figure 4 present data on the speech of the auricular and oral groups and the training each received. It is immediately seen that the auricular group have on the average received less training. The explanation of this is that the method of training has been introduced only recently.

Consideration of the data concerning the auricularly trained children leads to the following findings:

1. In general, and for all the elements examined, the speech of the children who have received the greatest amount of training deviates least from normal.

2. The progress, as defined, in the speech characteristics relative to expression, articulation and quality of vowel is particularly marked after the fifth year of training. For these elements there is a substantial difference between the children who have received less than 6

TABLE 5

FREQUENCY OF NORMAL ELEMENTS IN THE TRANSCRIBED SPEECH OF THE PUPILS OF THE PENNSYLVANIA SCHOOL FOR THE DEAF IN RELATION TO TYPE AND DURATION OF TRAINING RECEIVED

Duration of Training (in Years)

Speech Element	Method of Training	Less than 2		2-3		4-5		6-7		8-9		10-11		12 or over		Total	
		No.	Per cent Normal	No.	Per cent Normal	No.	Per cent Normal	No.	Per cent Normal	No.	Per cent Normal	No.	Per cent Normal	No.	Per cent Normal	No.	Per cent Normal
Expression	Auricular	13	7.67	31	3.23	39	15.38	22	36.36	13	30.77	---	---	---	---	118	16.95
	Oral	---	---	29	10.34	46	---	41	---	42	0.00	32	0.00	58	0.00	248	1.21
Articulation	Auricular	350	14.00	832	38.94	1045	34.64	593	78.25	351	85.47	---	---	---	---	3171	47.27
	Oral	---	---	783	18.14	1266	3.48	1107	1.17	1132	3.64	862	3.24	1554	0.00	6704	4.00
Quality of vowel	Auricular	349	18.91	833	54.98	1018	46.07	591	75.47	351	77.49	---	---	---	---	3142	54.46
	Oral	---	---	782	34.40	1262	13.07	961	4.58	1079	6.02	862	5.45	1458	3.22	6404	9.95
Holding of vowel	Auricular	348	40.52	829	66.59	1017	64.90	592	79.56	351	87.18	---	---	---	---	3137	67.90
	Oral	---	---	782	48.85	1261	41.63	963	34.27	1072	57.09	859	60.54	1457	73.23	6394	53.74
Explosiveness of vowel	Auricular	350	88.00	830	75.42	1016	75.39	593	83.88	351	96.30	---	---	---	---	3140	81.88
	Oral	---	---	782	74.55	1258	79.73	972	80.86	1075	90.70	856	89.25	1457	83.73	6400	83.30
Explosiveness of 1st Cons.	Auricular	312	80.13	739	80.65	910	86.92	528	91.10	312	90.38	---	---	---	---	2801	85.68
	Oral	---	---	697	78.91	1122	78.97	853	80.76	959	82.48	767	86.44	1292	85.68	5700	82.35
Audibility of 1st Cons.	Auricular	312	83.65	740	80.54	910	86.70	528	89.96	312	89.42	---	---	---	---	2802	85.65
	Oral	---	---	695	76.98	1121	78.06	864	79.75	959	82.27	767	86.44	1282	85.41	5688	81.58
Explosiveness of Final Cons.	Auricular	259	72.59	618	73.95	759	76.42	440	79.55	260	85.00	---	---	---	---	2336	76.88
	Oral	---	---	780	74.31	935	73.48	720	76.81	800	80.25	639	80.13	1080	83.06	4754	78.29
Audibility of Final Cons.	Auricular	272	70.22	648	69.44	797	69.89	461	75.49	276	80.43	---	---	---	---	2454	72.05
	Oral	---	---	619	60.42	985	63.81	762	68.50	840	76.07	669	73.99	1133	80.32	5008	70.67
Syllable Continuity	Auricular	26	65.38	62	66.13	76	78.95	44	86.36	24	100.00	---	---	---	---	232	77.59
	Oral	---	---	56	55.36	94	52.13	68	58.82	76	76.32	62	72.58	102	87.25	458	68.12

*Per cent of children in the case of expression, per cent of words spoken in the case of other elements.

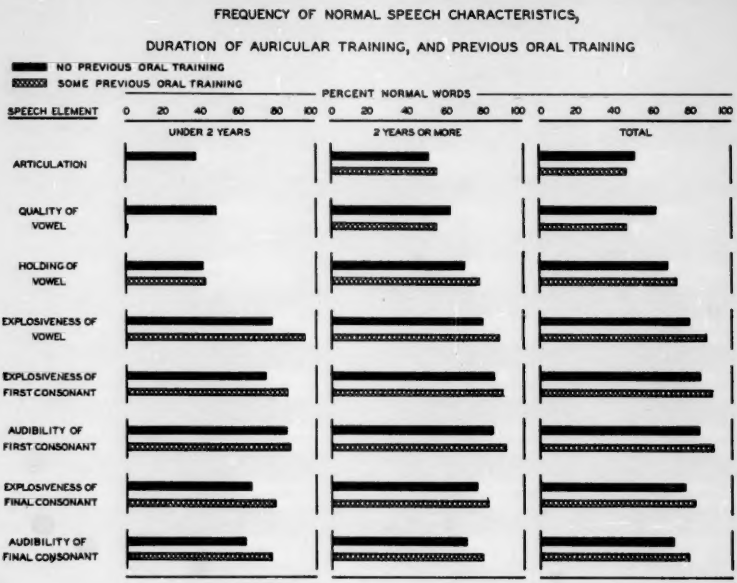

Figure 4

years of training and those who have been in class 6 years or more. In the case of articulation, for example, 34 per cent of the words spoken by the children with 4 or 5 years of training were classed as normal but this occurred for 78 per cent of the words spoken by the children with 6 or 7 years of training. The reason for this great difference in percentage, or improvement, is not known, but apparently it is not a consequence of some selective factor. It is well to recall, however, that these are data based on cross-sectional, not seriatim observations.

3. The greatest improvement with increase in the duration of training is observed especially for those elements that serve to differentiate particularly the speech of the profoundly deaf children from those with average hearing. Thus, the articulation was normal in 14 per cent of the words spoken by the children with less than two years of training and in 85 per cent of the words spoken by the children with 8 or 9 years of training. The latter percentage is more than five times the first. The corresponding percentages relative to explosiveness of final consonants are 73 and 85 and the latter is less than 1.2 times the former.

In summary, the progress due to increased training is clearly demonstrated in the case of the auricular group of children and particularly relative to those speech elements that are apparently most diffi-

cult to be acquired by the profoundly deaf child. The data on the oral group of children are in sharp contrast. From Table 5 and Figure 4 it appears that in the speech characteristics studied there is little progressive improvement with increased training. In the case of the three elements in which the deaf children show the greatest deficiency there would seem to be some retrogression rather than improvement with advancing years. For example, the children having two or three years of training repeated the words with normal expression, articulation and quality of vowel, respectively, in 10, 18, and 34 per cent of the cases. The corresponding percentages obtained from the records of the children having over 12 years of training are 0, 0, and 3. It is well to recognize that in the present evaluation of speech characteristics judgment is based on enunciation of single words, not phrases or sentences. Consequently the findings reported here are not to be interpreted to mean that the speech in general of the oral children retrogresses with duration of training but only those elements of the speech characteristics examined here. It is a common observation that those who are learning a foreign language pay greater attention to the pronunciation of the single words than do persons familiar with the language. The data shown here reveal that children receiving oral training tend to deteriorate in the speech characteristics studied even though their speech may improve otherwise with increased duration of training. On the other hand, the children receiving auricular training, with increased duration of training, improve also and particularly with reference to expression and articulation of words and quality of vowel pronunciation.

This difference in the results of the types of training is especially interesting from a practical standpoint when a comparison is made between auricular and oral groups with the longest duration of training. For none of the elements considered is the group with 12 or more years of oral training superior to the group with only 8 or 9 years of auricular training. It is seen from Table 5 that even with respect to the pronunciation of the first and final consonants and with regard to syllable continuity there is evident some superiority of this group, although it is only slight and between the corresponding percentages the differences are not statistically significant. Of course, relative to expression and articulation of words and the quality of the pronunciation of the vowel the achievement of the auricular group is never approximated by the oral.

From the above data one is led to infer that the methods of training are in themselves mainly responsible for differences in the speech characteristics of the two groups of children. This inference finds support from a comparison of the speech characteristics of children who had received, previous to their auricular training, a year or more of oral training and those of children who had no such training or at most less than one year. To simplify discussion the former will be labeled, "Some oral training", and the latter, "No oral training". It should be noted that the former sub-group is on the average older than the latter. The comparison is presented in Tables 6 and 7 and in Figure 4, already referred to.

From Table 6 (which omits data on expression of words and syllable continuity because the numbers become too small after subdivision) it is

TABLE 6

FREQUENCY OF NORMAL ELEMENTS IN THE TRANSCRIBED SPEECH OF THE PENNSYLVANIA SCHOOL FOR THE DEAF WHO ARE ENROLLED IN THE AURICULAR CLASSES IN RELATION TO PREVIOUS ORAL TRAINING

Speech Element	Previous Oral Training	Duration of Auricular Training: Under 2 — No.	Per cent Normal*	Duration of Auricular Training: 2 or More — No.	Per cent Normal*	Total — No.	Per cent Normal*
Articulation	None	135	36.30 ± 4.14	1802	50.44 ± 1.18	1937	49.46 ± 1.14
	Some	215	0.00 ---	1019	53.09 ± 1.56	1234	43.84 ± 1.41
Quality of Vowel	None	135	46.67 ± 4.29	1801	61.30 ± 1.15	1936	60.28 ± 1.11
	Some	214	1.40 ± .80	992	54.54 ± 1.58	1206	45.11 ± 1.43
Holding of vowel	None	134	40.30 ± 4.24	1798	67.96 ± 1.10	1932	66.05 ± 1.08
	Some	214	40.65 ± 3.36	991	77.40 ± 1.33	1205	70.87 ± 1.31
Explosiveness of vowel	None	135	76.30 ± 3.66	1799	78.21 ± .97	1934	78.08 ± .94
	Some	215	95.35 ± 1.44	991	86.38 ± 1.09	1206	87.98 ± .94
Explosiveness of 1st Cons.	None	120	73.33 ± 4.04	1602	83.71 ± .92	1722	82.98 ± .91
	Some	192	84.37 ± 2.62	887	91.21 ± .95	1079	89.99 ± .91
Audibility of 1st Cons.	None	120	82.50 ± 3.47	1603	83.47 ± .93	1723	83.40 ± .90
	Some	192	84.37 ± 2.62	887	90.30 ± .99	1079	89.25 ± .94
Explosiveness of Final Cons.	None	100	65.00 ± 4.77	1338	75.41 ± 1.18	1438	74.69 ± 1.15
	Some	159	77.36 ± 3.32	739	81.06 ± 1.44	898	80.40 ± 1.32
Audibility of Final Cons.	None	105	61.90 ± 4.74	1406	69.49 ± 1.23	1511	68.96 ± 1.19
	Some	167	75.45 ± 3.33	776	77.32 ± 1.50	943	76.99 ± 1.38

*Per cent of children in the case of expression, per cent of words spoken in the case of other elements.

seen first, when the total is considered, that the children with no oral training are superior to those with some oral training with respect to articulation of words and quality of vowel. In both the differences in the percentages are statistically significant. Relative to these two elements the bulk of the differences between the auricular children who received some oral training and those who did not is due to the differences in the case of children who have received less than two years of auricular training. The data of Table 6 show that among such children 36 per cent of the words spoken by those with no oral training exhibited normal articulation but this was observed in none of the children who had had some oral training. The percentages are 47 and 1, respectively, for quality of vowel. Thus, when the children have been subjected to only a short duration of auricular training those with previous oral training do not respond to the same degree to auricular training as do the children with no previous oral training.

The reverse is seen in the case of explosiveness of vowel and of consonants, and audibility of consonants. In total, the children with some oral training exhibit higher percentages of normally spoken words than the others. These differences can be traced also to the differences to be observed for children with less than two years of auricular training. In Table 1 it was shown that, relative to explosiveness and audibility of consonant, especially, the orally trained children spoke a higher number of words with normal characteristics. The same is shown in Table 6. It was also seen in Table 1 that relative to these elements the proportion of words spoken with hypernormal emphasis is higher in the auricularly trained children. The data presented in Table 7 bring out the same for the children who have received little or no oral training as compared to those children who were enrolled for a year or more in oral classes prior to entering the auricular group. From Table 7 it appears that for the elements considered, while the children with some previous oral training spoke a higher proportion of words normally than did the children with no previous training, the latter were observed to enunciate with a greater than normal emphasis more often than the former. Taking these findings together with those of Tables 1 and 6 it would seem safe to infer that the two methods lead to a difference in the speech characteristics of the children subjected to each type of training. The difference is such that once the child has been trained by the oral technique and is transferred to the auricular group he conserves the traits acquired during the former type of training and for some time his speech characteristics will resemble, in comparison to the children with no such training, those of the oral group when compared to the auricular. From all this it follows, that all other things being equal, the children who receive auricular training in comparison with those who receive oral teaching pronounce words with:

1. Less deviation from normal articulation and expression and from normal enunciation of vowel.

2. Greater than normal emphasis in the pronunication of the consonants.

TABLE 7

SPEECH CHARACTERISTICS OF CHILDREN HAVING LESS THAN TWO YEARS OF AURICULAR TRAINING AND CLASSIFIED ACCORDING TO PREVIOUS ORAL TRAINING

Speech Element	Previous Oral Training	Defined grade and percentage of words spoken: Less than Normal No.	Less than Normal Per cent	Normal No.	Normal Per cent	Greater than Normal No.	Greater than Normal Per cent
Explosiveness of vowel	None	0	0.00 ——	103	76.30 ±3.66	32	23.70 ±3.66
	Some	0	0.00 ——	205	95.35 ±1.44	10	4.65 ±1.44
Explosiveness of 1st Cons.	None	6	5.00 ±1.99	88	73.33 ±4.04	26	21.67 ±3.76
	Some	29	15.10 ±2.58	162	84.37 ±2.62	1	0.52 ± .52
Audibility of 1st Cons.	None	5	4.17 ±1.82	99	82.50 ±3.47	16	13.33 ±3.10
	Some	29	15.10 ±2.58	162	84.37 ±2.62	1	0.52 ± .52
Explosiveness of Final Cons.	None	6	6.00 ±2.37	65	65.00 ±4.77	29	29.00 ±4.54
	Some	26	16.35 ±2.93	123	77.36 ±3.32	10	6.29 ±1.92
Audibility of Final Cons.	None	6	5.71 ±2.26	65	61.90 ±4.74	34	32.38 ±4.57
	Some	27	16.17 ±2.85	126	75.45 ±3.33	14	8.38 ±2.14

DISCUSSION

It is felt that the data reported above should serve a twofold purpose. In the first place, a method of studying voice characteristics of deafened children is presented. Undoubtedly modification of the method will result not only from further experience in its use but also by weighing the importance of suggested changes of which there will surely be many. In the second place, it is shown that regardless of age of onset, degree or duration of hearing loss, one teaching method, the auricular, is basically superior to the oral for all children with any residual hearing. This feeling has been current for some time amongst teachers of the deaf who have had experience with the auricular method. The present study confirms their opinion and further points the way toward an even wider application of the technic than had previously been thought possible. From these data it must be concluded that the young deaf child should be given the opportunity to receive this auricular training on admission to schools for the deaf. There is no evidence that auricular training will prove a handicap to a child who might eventually have to be transferred to the oral group.

One further point warrants elaboration, since some references has already been made to it. The expense for education of handicapped children is relatively large. This type of education has for its chief purpose the training of a handicapped child to be a self-supporting and independent individual. The handicap of itself increases the required years of training before high school certification can be gained. In schools for normal children there is a normal sequence of achievement for all pupils. In schools for handicapped children progress depends solely upon the individual child's ability to surmount the handicap. If it is possible to lower this particular barrier in any way much will have been accomplished.

It can be conservatively estimated on the basis of these findings that the total period of education will be shortened by two years. If

a child is in residence at a deaf school for 14 years, this means a reduction in time of one-seventh. A typical maintenance cost as exemplified in the Pennsylvania School for the Deaf is $635.00 per child per year. Every child who goes through high school and the two additional years required to obtain a vocational training certificate represents an outlay of $8,890.00. Auricular training shortens this total period by approximately two years, resulting in a saving of $1,270.00 per child so trained. It would seem that direct sponsorship of this auricular program by state boards of special education would be a practical method of furthering the education of the deaf child and at the same time would achieve greater economy.

SUMMARY

1. The speech characteristics of 367 children, resident in the Pennsylvania School for the Deaf, have been studied. Of this group, 249 had never received auricular training at the time of the study; 118 were enrolled in auricular classes.

2. In general, comparison of the two groups shows that the speech of children given auricular training tends more toward that of the normal child than does that of the oral group.

3. Under all conditions of residual auditory acuity the speech of the children trained by the auricular method is superior to that of the other children. Residual auditory acuity in children trained by the oral method apparently has no bearing on speech response.

4. The superiority of the auricularly trained children is noted regardless of age of onset of deafness, although in both groups of children there is a definite tendency for improvement in speech as the age of onset of deafness is raised.

5. With advancing age there is some improvement in the speech characteristics of both groups of children which is more marked in the children trained by the auricular method. At equal age, however, the superiority of the latter over the children trained by the oral method always persists.

6. In children trained by the auricular method there is continuous improvement in speech characteristics with duration of training. No comparable improvement is observed for children trained by the oral method.

7. Children who receive oral training and are eventually placed in auricular classes are apparently retarded in their acquisition of speech.

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THE VARIABILITY OF WEIGHT AND HEIGHT INCREMENTS FROM BIRTH TO SIX YEARS

MEINHARD ROBINOW[1]

Much time and effort has been expanded on the establishment of height and weight norms for normal children. Such norms fill an obvious need. They classify children and they are useful for studying progress over relatively long periods of time. However, for following the progress of children over shorter periods it is far more helpful to study growth increments. Norms for mean growth increments can be easily obtained from the usual height and weight tables (mean increment = difference between means at successive age levels). But the variability of increments must be calculated from raw data. Such norms have apparently not been published. This study was undertaken because it was felt that such norms can be of value to all interested in the progress of normal and abnormal children.

Material and Methods

About 170 normal white children are examined at regular intervals at the Samuel S. Fels Institute. The majority of the children come from upper middle class homes. Their mean heights and weights are approximately midway between the norms of Woodbury (2) and Peatman and Higgins (1). The children are weighed and measured without their clothes. In establishing these standards values were omitted if children were more than a few days off schedule.[2] If visits were off schedule but within this tolerance the increments were corrected for the difference. Norms for boys and girls were at first calculated separately but were combined later since the differences were not statistically significant.

Some difficulty arose in deciding which cases should be excluded because of illness. It was finally decided to eliminate only two children who suffered from severe chronic illnesses which finally lead to death. All other cases were included for the following reasons: children who were acutely ill at or shortly preceding the scheduled appointments were automatically eliminated since children are not brought to the Institute during illnesses. There remain two other groups: 1) the children who had minor colds, gastro-intestinal upsets or other minor disturbances unlikely to change growth appreciably, and 2) those who had shown clinical recovery from more serious illnesses but who had not yet regained their weight. This latter group is very small; it was not omitted since decision on individual cases would have been too arbitrary.

Results

The intervals for which increments were calculated increase from one month (birth to one month) to six months (all increments after the first year). The intervals correspond to roughly equivalent periods of growth. For instance, the mean length increment during the first month is the same as the increment during the period from 36 to 42 months.

[1] *From the Samuel S. Fels Research Institute, Antioch College, Yellow Springs, Ohio.*

[2] *The tolerance was increased from 3 days at 1 month to 1 week at 1 year, 2 weeks from 3 years on.*

Weight increments are presented in Table 1. Columns 1 - 4 give age intervals, number of cases, mean increments and their standard deviations. Column 5 shows the coefficient of variability $\left(\frac{100.\sigma}{\text{mean}}\right)$, the conventional measure of variability. The figures in column 6 are the reciprocal, $\frac{\text{mean}}{\sigma}$. The percentage figures in columns 7 and 8 represent the children who may be expected to gain or lose weight during the interval. By definition, a child whose increment is $\frac{\text{mean}}{\sigma}$.σ below the mean does not gain weight. The figures in column 7 represent one-half of the normal distribution plus the area under the normal curve occupied by $\frac{\text{mean}}{\sigma}$. The chances that a normal child (normal as by our definition) will lose weight during the period from 3 to 6 months are less than 1 to 1000, while the chances during the period from 9 to 12 months are 1 to 33, from 5½ to 6 years even 1 to 18. The clinical interpretation would be as follows: Failure of a child to gain weight during the 3 to 6 months period is far more serious than failure during the 9 to 12 months period. These statements are made with the assumption that weight increments show a normal distribution. This is actually very closely approximated.

The relative variability of increments tends to vary inversely with the length of the intervals and the size of the increment. Longer intervals obscure the effects of minor temporary gains and losses. But the variability of a given increment cannot be used to calculate the variability of any other increment during a longer or shorter interval. These facts are illustrated by a series of yearly weight increments which had previously been calculated on the Fels group (Table 2).[3]

Comparable norms were also calculated for crown-heel length increments (Table 3). The variability of these increments is more uniform throughout the age range. The relative variability is distinctly smaller in spite of the fact that length cannot be measured as accurately as weight and that inaccuracy increases the variability. But the lower variability of the length increments is not surprising. It is well known that length is less affected by environmental factors than weight. Only the most severe disturbances arrest longitudinal growth. Negative increments, that is, losses, can occur only for weight.

Throughout the first year the rate of growth decelerates rapidly (see figure). From 3 to 6 months height and weight increase almost twice as rapidly as from 9 to 12 months. During this period the relative variability of the weight increments increases far more than the variability of the length increments. The following explanation seems most likely: Weight increments tend to be variable at periods when overweight is common. Many infants gain weight very rapidly until the middle or second half of the first year. They become temporarily quite fat, but after this period their weight may remain almost stationary for several months. Other infants gain weight less rapidly during the early months but continue to gain more steadily. At 18 months both weight and weight/length ratio are less variable than at 6 or 9 months. Most children have again become fairly slender. Longitudinal growth shows no comparable phenomenon.

[3] *The composition of the group was slightly different at that time.*

TABLE 1

WEIGHT INCREMENTS DURING SUCCESSIVE PERIODS FROM BIRTH TO SIX YEARS
BOYS AND GIRLS COMBINED

1	2	3		4		5	6	7	8	9
Age in months	Number of cases	Mean Increment Kgs	Lbs	Standard Deviation Kgs	Lbs	100.σ mean	mean / σ	% gaining weight	% losing weight	percentage increment x)
0-1	128	.62	1:6	.29	0:10	46.0	2.18	98.5	1.5	16.35
1-3	134	1.54	3:6	.50	1:2	36.2	3.11	99.9	0.1	31.62
3-6	133	1.77	3:14	.51	1:2	28.6	3.49	99.9	0.1	27.13
6-9	130	1.35	3:0	.47	1:1	35.1	2.85	99.8	0.2	16.70
9-12	128	.99	2:3	.53	1:3	53.3	1.88	97.0	3.0	10.70
12-18	121	1.38	3:1	.55	1:4	40.0	2.50	99.4	0.6	14.62
18-24	117	1.20	2:11	.46	1:0	38.0	2.63	99.6	0.4	10.23
24-30	108	1.02	2:4	.53	1:3	52.4	1.91	97.2	2.8	7.89
30-36	103	.96	2:2	.41	0:14	42.5	2.35	99.1	0.9	6.94
36-42	99	1.02	2:4	.46	1:0	49.7	2.24	98.7	1.3	6.88
42-48	96	.96	2:2	.51	1:2	53.1	1.88	97.0	3.0	6.07
48-54	89	1.10	2:7	.55	1:4	50.0	2.00	97.7	2.3	6.53
54-60	84	.98	2:3	.45	1:0	45.9	2.18	98.5	1.5	5.48
60-66	85	1.13	2:8	.55	1:4	48.7	2.05	98.0	2.0	5.97
66-72	82	1.15	2:9	.72	1:10	62.6	1.60	94.5	5.5	5.73

x) $\frac{2i}{W_1 + W_2}$ For explanation see text

i = increment
W_1 = weight at beginning of period
W_2 = weight at end of period

TABLE 2

ANNUAL WEIGHT INCREMENTS

Age in Years	Boys					Girls				
	Mean Increment		Standard Deviation		$\frac{100.\sigma}{\text{mean}}$	Mean Increment		Standard Deviation		$\frac{100.\sigma}{\text{mean}}$
	Kgs	Lbs	Kgs	Lbs		Kgs	Lbs	Kgs	Lbs	
0-1	6.62	14:10	.96	2:2	14.5	6.04	13:5	.86	1:14	14.2
1-2	2.70	5:15	.64	1:7	23.7	2.53	5:9	.73	1:10	28.9
2-3	2.03	4:8	.55	1:4	27.1	2.00	4:7	.62	1:6	31.0
3-4	2.09	4:10	.56	1:4	26.8	1.95	4:5	.63	1:6	32.3
4-5	2.28	5:0	.61	1:6	26.8	2.06	4:9	.74	1:10	35.9

TABLE 3

LENGTH INCREMENTS DURING SUCCESSIVE PERIODS FROM BIRTH TO SIX YEARS
BOYS AND GIRLS COMBINED

Age in months	Number of cases	Mean Increments cm	inches	Standard Deviation cm	inches	$\frac{100.\sigma}{\text{mean}}$	Percentage increment
0-1	76	3.85	1.52	.85	.33	22.1	7.39
1-3	103	6.08	2.39	1.37	.54	22.6	10.66
3-6	111	6.33	2.49	1.29	.51	20.3	10.01
6-9	117	4.44	1.75	1.13	.44	25.5	6.52
9-12	121	3.93	1.55	1.07	.42	27.1	5.40
12-18	118	6.60	2.60	1.16	.46	17.6	8.45
18-24	116	5.46	2.15	1.13	.44	20.7	6.49
24-30	106	4.74	1.87	.97	.38	20.4	5.31
30-36	101	4.20	1.65	.98	.39	23.4	4.48
36-42	99	3.84	1.51	.81	.32	22.0	3.93
42-48	95	3.52	1.38	.76	.30	21.5	3.45
48-54	91	3.66	1.44	.85	.33	23.2	3.53
54-60	87	3.40	1.34	.65	.26	19.0	3.13
60-66	82	3.42	1.35	.72	.28	21.1	3.04
66-72	82	3.24	1.28	.65	.26	20.2	2.78

From 2 to 6 years absolute weight increments remain practically constant while length increments continue to become smaller. Relative increments, that is, per cent of attained weight and length (last columns Tables 1 and 3 and figure), decrease throughout the period for both variables. They illustrate the deceleration of growth more strikingly than the absolute increments.

SUMMARY

Norms were established for increments of weight and length during successive intervals from birth to six years.

The variability of these increments presents several problems of theoretical and practical interest.

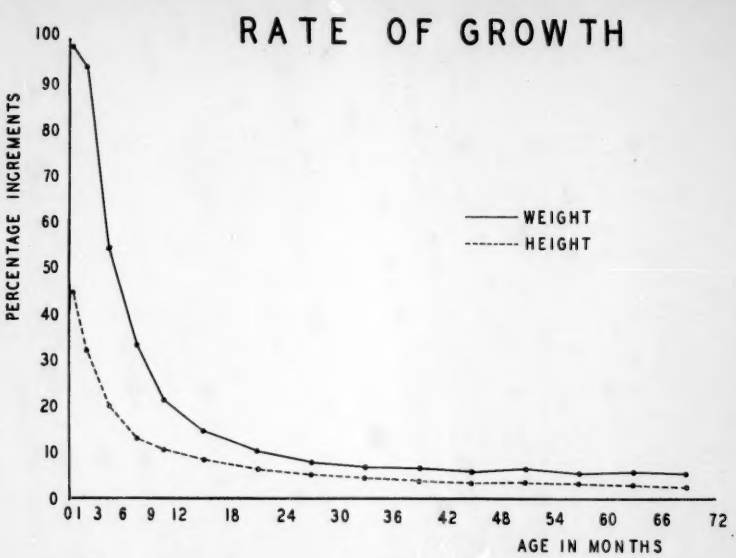

Figure 1. Rate of Growth for Weight and Length. All figures were calculated on the bases of six months increments. For instance, the first point represents six times the percentage increment during the first month. The curves approximate the function $\frac{d \text{ increment}}{d \text{ time}}$.

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